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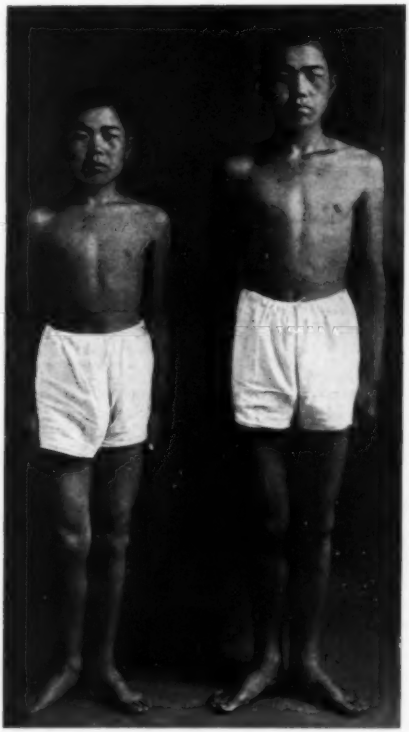

IDENTICAL TWINS REARED TOGETHER

(SEE PAGE 423)

Missing Teeth Inherited

Three New Genes of Datura

Woolly Hair in Hereford Cattle

A Visit to Corbeil

Genetics and Embryology

"Sporadic" Flightless Fowls

VOLUME 25 OCTOBER, 1934 NUMBER 10

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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The

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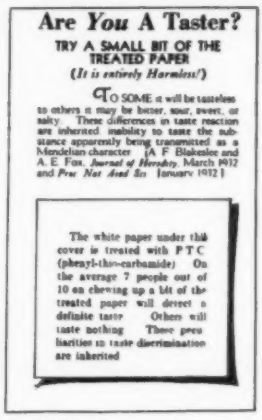
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TRY A SMALL BIT OF THE TREATED PAPER
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TO SOME it will be tasteless to others it may be bitter, sour, sweet, or salty. These differences in taste reaction are inherited inability to taste the substance apparently being transmitted as a Mendelian character [A. F. Blakeslee and A. E. Fox, *Journal of Heredity*, March 1932 and *Proc. Nat. Acad. Sci.* January 1932]
The white paper under this cover is treated with P T C (phenyl-thio-carbamide) On the average 7 people out of 10 on chewing up a bit of the treated paper will detect a definite taste Others will taste nothing These peculiarities in taste discrimination are inherited

LEAFLETS TO DEMONSTRATE HEREDITY

Last year the "Taster test" served as an introduction to human genetic differences in many classrooms. The test is so easily made with the treated paper, and arouses such great interest that it appears to have a definite place in group demonstrations of such differences. These leaflets, size 3⅜″ by 5½″, are available in quantities for those who wish to use them for classroom or lecture purposes. On the back is printed an outline 4-generation pedigree chart. Sample on request. Prices: 10 for 25c; 50 for $1.00. 7″ by 10″ size, containing larger chart and more extended discussion of sense differences, 5 for 25c; 30 for $1.00.

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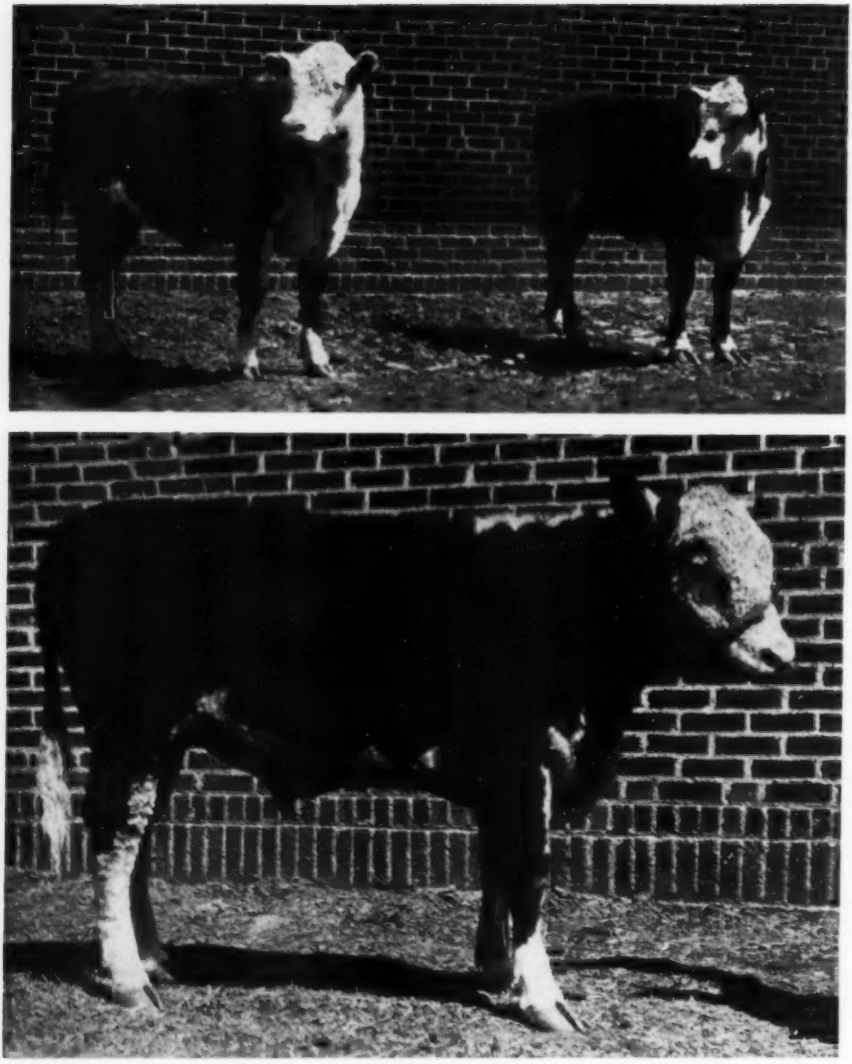


SEMI-HAIRLESS CATTLE

Frontispiece

Two heifers (Nos. 013 and 014) and a bull (No. 015) showing the semi-hairless character found in a herd in Oklahoma. The hair is curly and of flat or oval cross section, suggesting the "woolly" type of swine discussed in the preceding number of the JOURNAL. This characteristic behaves as a recessive in inheritance, not as a dominant as does the "woolly" mutation. The semi-hairless cattle are noticeably wilder than their normal sibs, and it is possible that they may be somewhat less hardy.

THE INHERITANCE OF SEMI-HAIRLESSNESS IN CATTLE

W. A. Craft and W. L. Blizzard
*Oklahoma A. and M. College and Agricultural Experiment Station**

HAIRLESSNESS (hypotrichosis) appears to be widespread among mammals. It has been reported in some cases as being due to a deficiency of iodine in the ration, particularly in new-born pigs. Welch[12] from a study of hairlessness and goiter in new-born animals in a region of Montana, assigned hairlessness in pigs, lambs and calves, and weakness in colts as being due to a disturbance of the function of the thyroid gland. He observed that the enlarged thyroids were deficient in iodine. Welch does not mention hairlessness in calves or lambs as having occurred in the absence of goiter, and he points out that hairlessness and goiter were not as conspicuous in foals as in the other species.

Smith[9] pointed out that iodine deficiency during pregnancy causes a lack of function and hyperplasia of the fetal thyroid, and that this results in an arrested development of the fetus, also that fetal athyrosis is evidence of a direct relation between the physiologically active constituents of the thyroid and growth of the epidermal appendages. Hart and Steenbock[3] conclude that the hairless pig malady is occasioned by a low iodine assimilation by either intestine, or thyroid, which results in a goitrous condition in both mother and young.

Cole[1] observed defective hair and teeth in a herd of Holstein-Friesian cattle in Wisconsin, and it was suggested that the disturbance might be attributed to a genetic cause rather than to factors of the environment, or to faulty nutrition.

Mohr and Wriedt[5] reported observations on hairless calves in the Holstein-Friesian breed of cattle in Europe and concluded that the condition was hereditary, being a simple recessive. It was pointed out that a homozygous combination of the recessive genes is lethal, and produces an almost complete hairlessness (hypotrichosis congenita). Microscopical examination of the hairless skin revealed that the development of the hair follicles and their appendages was markedly delayed. As compared with the hair follicles the sweat glands had undergone a premature development resulting in a general and rather striking cystic enlargement. Furthermore, it was pointed out that the skin of the hairy areas appeared normal. Almost the entire skin was completely hairless, the surface was smooth and glossy, and the unpigmented areas were pink.

Hairless rats and mice have been reported by several different observers. Sumner[11] presented evidence which was interpreted by him to indicate that hairlessness in his stock of mice was due to a single recessive gene.

Snell[10] reported two types of hairlessness in the house mouse. One was found to be a simple recessive, and the other a dominant which was described as naked. The latter was observed to be entirely independent of the former, the genes being located on different chromosomes.

Wilder et al,[13] in a recent article, reported a hereditary hairless condition in rats in which the hairless rats were normal in weight and size at birth. The hair grew in as in normal rats, but about the 19th or 20th day a hairless ring appeared around the

*Published with the approval of the Director of the Station.

mouth, and by the 23rd day the hair had begun to fall out all over the body, and within a few days the animal was completely hairless. Hair began to come in on the shoulders and back three to four months later, but this coat was thin and the hairs grew to be long and coarse. A sexual dimorphism was observed, hair regeneration was greater in males than in females. After about a month this hair was shed and the skin became flabby, and deep folds appeared around the head, neck, and legs. Furthermore, on aging the skin was covered with small scaly lumps, and sores, the toe nails grew abnormally long and curved. These hairless rats lived only about one-third as long as normals. The females were frequently sterile, but the males approached the normal in fertility.

It was concluded that this condition is due to a simple Mendelian recessive and that it is not linked to albino. A similar case has been observed in the mouse by Crew and Mirskaia[2] and was found to be a recessive trait.

Roberts[7] reported that in his studies with hairless rats histological examination of the thyroids and adrenal glands failed to show abnormalities. Matings of individuals heterozygous for the suspected recessive gene produced 909 haired to 293 hairless, and the back-cross produced 184 haired to 176 hairless. In a later report Roberts and Carroll[8] pointed out that the administration of iodine and cystine failed to promote hair growth in the case of the hairless rats.

Hairlessness in rabbits has been reported by Kislovsky.[4] He suggested that this defect appears to be inherited as a simple recessive. Defects in the teeth were also observed, and none of the hairless rabbits lived more than a month.

Popova-Wassina[6] reported a hairless or naked condition in sheep. The case is described as being almost completely void of wool or hair except for a small amount of hair on the dorsal surface of the hind tibiae and some hair on the tip of the tail. Only one case was observed, but the possibility of the trait being hereditary was suggested.

Roberts and Carroll have made a genetic study of the hairless condition characteristic of the Mexican hairless swine. It was found that the normal condition is incompletely dominant to the hairless. The hairless × hairless matings produced hairless offspring, and the heterozygous genotypes were somewhat intermediate between normal-haired and hairless. Furthermore, it was pointed out "that this type of hypotrichosis or hairlessness is entirely distinct from the hairlessness prevalent in certain regions of the United States, which is caused by a deficiency of iodine probably associated with goiter in the mother. In the latter kind the young are either born dead or die within a few hours after birth. The administration of iodine will prevent the occurrence of this type, but the hairlessness of the Mexican swine cannot be prevented in this way."

Semi-Hairless Cattle in Oklahoma

Early in 1932 a herd of cattle in Oklahoma came to the attention of the present writers, in which a number of semi-hairless calves had been produced. A purebred Polled Hereford bull had been used in this herd on mixed grade cows for several years. The first semi-hairless calf was dropped in 1926, another in 1927, two in 1928, two in 1929, three in 1930, five in 1931, three in 1932, and three in 1933. Thirty-five to forty cows were kept in this herd during the years mentioned. The owner estimated that about 260 calves had been dropped during the years mentioned, and his records show that 22 were semi-hairless.

In February, 1932, the senior author visited the farm and inspected the cattle on hand at the time. So far as could be determined conditions on this farm were favorable. Hairless pigs

or goitrous conditions had not been observed in other animals produced in the community. The county agricultural agent was consulted and goitrous conditions and other hairless animals had not come to his attention.* Early in 1933 potassium iodide was included in a mineral mixture used on this farm. But three cows dropped full term semi-hairless calves during 1933 after they had been self-fed the mineral mixture containing potassium iodide.

The semi-hairless calves were sired by two different bulls that were distantly related by being line-bred to the same bull. According to the record given by the owner of this herd of cattle, the first semi-hairless calf was dropped by a heifer which was sired by a grade Polled Hereford bull and out of a grade Shorthorn cow. This calf was sired by a purebred Polled Hereford bull. The second calf of this heifer from mating to the same bull as before was normal, but the third calf was semi-hairless. The dam of these calves was disposed of but the next year another cow dropped a semi-hairless calf. Later normal daughters of the bull that sired the first semi-hairless calves were producing, and some of these produced semi-hairless calves when mated to a bull that was distantly related to their sire.

Records on three additional cows in the herd show that one produced five normal and one semi-hairless, another produced four normal and one semi-hairless, and the third cow produced one normal and one semi-hairless calf. Thus complete records on four cows show 11 normal and 5 semi-hairless calves. This is in close agreement with the expected for matings of heterozygous genotypes, if semi-hairless is a simple recessive trait.

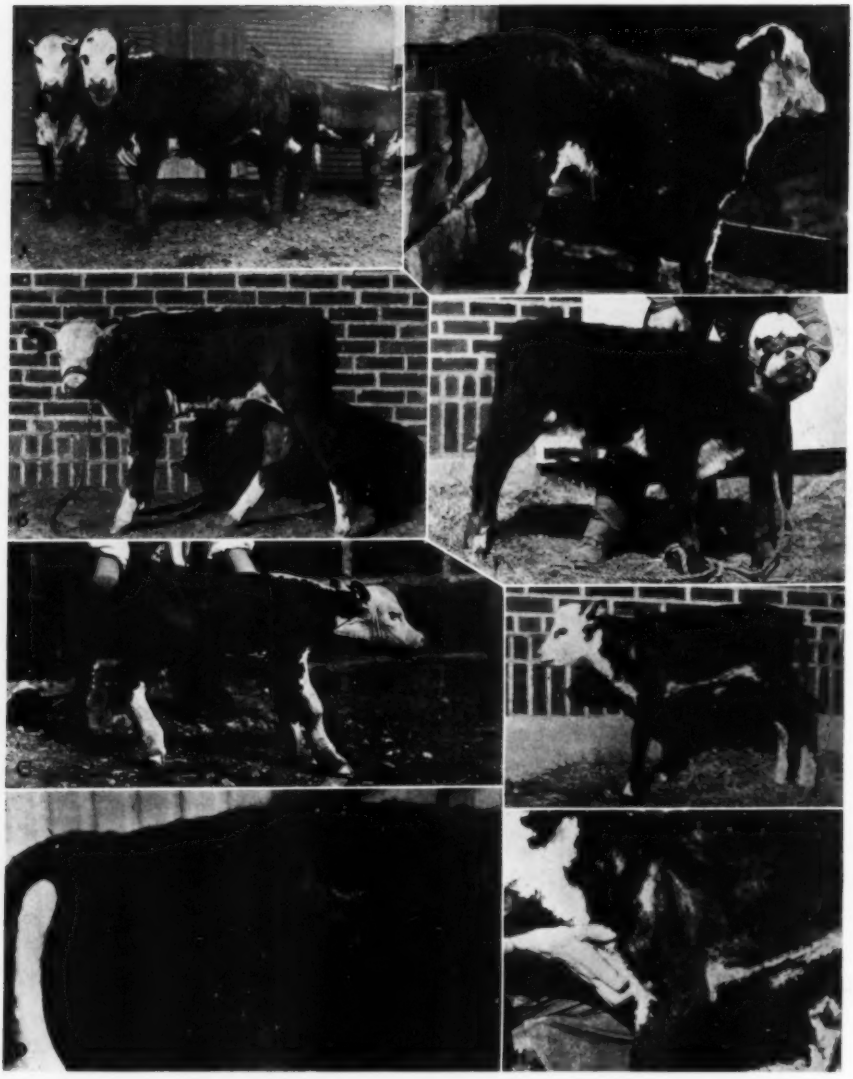
The owner states that these semi-hairless calves were born with a very thin coat of short, fine, curly hair, and that hair of a coarser nature began to appear within two or three weeks after birth. Furthermore, that the calves were about normal in size but they were thin in flesh at birth. He also states that some of the semi-hairless calves were kept for more than a year but they did not develop a normal coat, and the hair continued to be thin, became coarse and wiry, and that the affected calves did not grow satisfactorily.

The photographs shown in Figure 1*A* and *E* were taken at the time the herd was inspected. These photographs show the condition of the coat for three yearling heifers (Figure 1*A*), and one calf two months old (Figure 1*E*). It is apparent that there is a deficiency of hair on these animals. They also showed evidence of more wildness than was observed in the normal-haired stock. More recently another herd of Polled Herefords in Texas in which some hairless calves have been dropped has come to the attention of the writers. It is reported that one or two hairless calves have been born at intervals for several years, but records on these are not available at this time.

Experimental Results

Three normal-haired cows that had produced semi-hairless calves, two semi-hairless heifers and one semi-hairless bull were purchased from this herd and moved to the Oklahoma Agricultural Experiment Station. Each of these three cows was bred to the bull that had sired the last semi-hairless calves dropped on the farm where they came from. These cows dropped calves about six months after they arrived at the Experiment

*The authors are indebted to Dr. L. H. Moe and Professor C. P. Thompson (of the Oklahoma A. & M. College Veterinary Science and Animal Husbandry Departments respectively) for aid in making an inspection of the cattle, sanitary conditions on the farm, and of the rations used. Dr. Moe has given assistance with the experimental animals at different times.



SEMI-HAIRLESS AND NORMAL COMPARED

Figure 1

A—Three yearling semi-hairless heifers. Note the thinness of the coat and the bare patches. *B*—Normal haired calf of cow 15, the hair was shorter at birth than usual but at three weeks of age it appeared entirely normal. *C*—Semi-hairless calf born prematurely (eight months). All the semi-hairless calves observed at the Oklahoma Station have had scaly and wrinkled skin. The hair of the legs and back is longer and thicker than elsewhere. *D-E*—Two views of heifer 013. *D* is a close-up of the side of the heifer when about six months old. Note the wavy hair. *E* shows this same heifer at two months. Hair was very short on the margins of the ears. *F*—Normal calf of cow 15. The hair is unusually stiff and wiry. *G-H*—Semi-hairless calf of cow 15 by bull 015 (Frontispiece). Both parents are semi-hairless. Note the characteristic bare areas.

Station. Number 14 produced a male calf with a normal hair-coat, except that the hair was very short at birth, but at about three weeks of age the hair appeared very similar to the normal calves in the herd (Figure 1*B*). The cow (No. 14) was then bred to a purebred normal Shorthorn bull and dropped a calf at full term, which had normal hair except that it was shorter than the hair on other new-born calves in the herd. The second cow (No. 13) bred to the same bull as was No. 14 dropped a normal-haired calf. She was then bred to a purebred Hereford bull and a normal-haired female calf was produced. The third cow (No. 15) bred to the same bull as Nos. 13 and 14 dropped a male calf that had a normal amount of hair, but it was noticeably coarse, and wiry (Figure 1 *F*). This characteristic was evident when the calf was eight months old. Number 15 was then mated to her son the semi-hairless bull (015) purchased with the cows, and she dropped a semi-hairless female calf, two photographs of this calf are shown in Figure 1*G* and *H*.

The two semi-hairless heifers (013 and 014) were bred to the semi-hairless bull (015). Eight months after service 014 dropped a semi-hairless female calf which lived about four hours. The other heifer 013 dropped a live-born bull calf seven months and four days after service. This calf was weak but very active. Shortly before these heifers calved they had shown positive tests for abortion disease. But at the time the cattle were purchased they all had given negative tests and the abortion disease was not prevalent in the herd where these animals came from. A photograph of 013 and 014 is shown in Frontispiece.

Each of the semi-hairless calves has shown the same characteristics, with the exception that the pre-term calves had much shorter hair than that of the full term calf (Figure 1*C*). Hair was absent at the margin of the ears, areas along the ventral side from the sternum to the udder, on the inside of the legs, and areas along the sides of the neck, shoulder vein, sides, and thighs. The tail was almost bare and brush-hair at the tip of the tail was lacking. In the bare areas the skin was pink and showed a greater tendency to wrinkle than in the hairy areas. The skin becomes scurfy and dry after a few weeks.

The heifers and the bull (013, 014 and 015) have not grown as well as the normal cattle that they have been raised with, and they decidedly lack a normal hair-coat. The bull (015) has developed more hair than the heifers but the coat is not normal, the hair is thin, short, wiry, coarse and curly (Frontispiece). The hair appears to shed from the follicles very easily on the semi-hairless animals. In certain areas the hair also appears to break off relatively close to the skin (Figure 1*D*).

Microscopical observations on hair taken from one of the semi-hairless calves show that the hairs have a tendency to be somewhat flat and spiral. Furthermore, these observations so far have not revealed constrictions or other abnormal appearance of the hairs.

Sections of skin from one of the pre-term calves showed some of the hair follicles prematurely developed, and hairs were not formed in the premature follicles. Cysts were not observed, however.

Although the normal-haired cows, which were purchased from the farm where semi-hairless calves had been produced, were wild when they were brought to the Station herd they have since become relatively tame. But the semi-hairless animals continue to be wild.

Summary

1. Observations made in a grade herd of Polled Herefords in Oklahoma suggest that a condition of semi-hairlessness is a hereditary recessive trait in cattle. It is not lethal but the af-

fected calves do not grow as well as those with normal hair. The semi-hairless animals appear to be wild.

2. Experimental matings of stock procured from the herd described further substantiate the suggestion that the semi-hairless condition is a hereditary recessive character.

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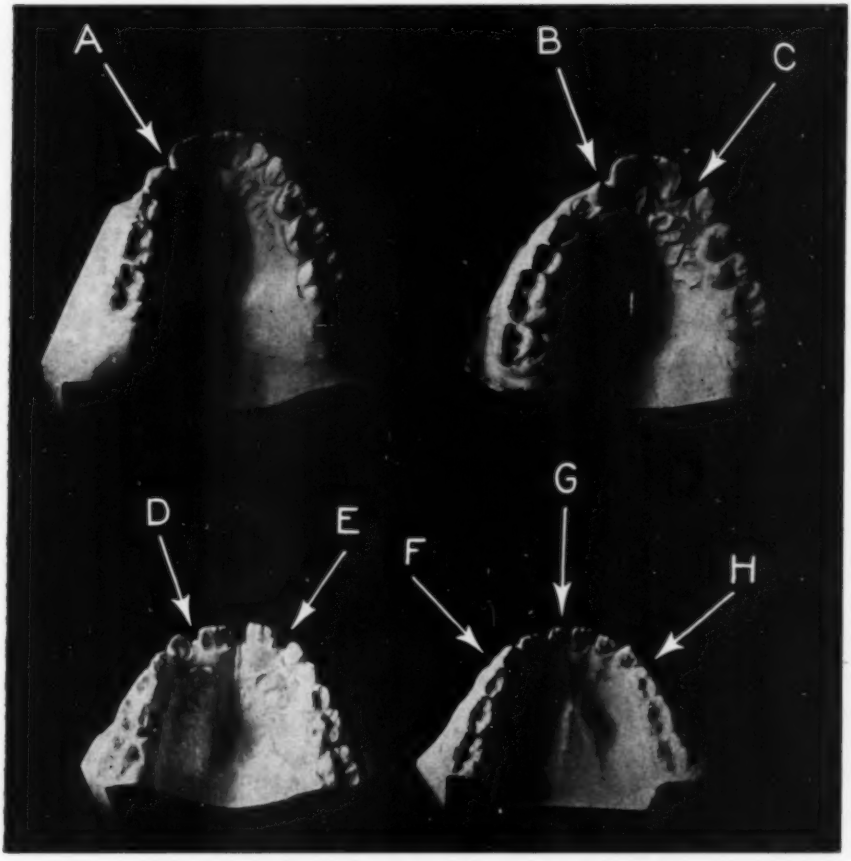
Poultry Research in Review

A THIRTY-TWO page booklet emanating from the Institute of American Poultry Industry, 110 North Franklin St., Chicago, Ill., contains a useful summary in very brief form of the present status of research problems in poultry. All branches of research affecting the poultry industry are included and it is interesting to note what an important part genetics plays in the program.

It appears that in the two years, June, 1930, to June, 1932, approximately $420,000 was spent in research by the poultry departments of the colleges and experiment stations. Other considerable sums were spent by the U. S. Department of Agriculture and by private agencies. Four-fifths of this money was spent in studies of production, preparation, and marketing, and the balance in allied industries in studies of consumption and in such matters as building and equipment. By far the largest part was spent on the study of the basis of the poultry industry, the domestic fowl itself. Of this three hundred thousand dollars roughly a quarter ($75,000) was expended on genetic research and on breeding projects,—to discover the genetic basis of such matters as egg production, hatchability, viability, size and shape of egg, disease resistance, hybrid vigor, etc. It is held that the most important single objective at the present time is the production of "proved roosters" capable of transmitting desirable characteristics much as the proved sires of the dairy industry have contributed to the production of high quality dairy herds.

HEREDITARY ABSENCE OF UPPER LATERAL INCISORS

CLYDE E. KEELER AND RALPH SHORT
Howe Laboratory, Harvard Medical School, and Forsyth Dental Infirmary



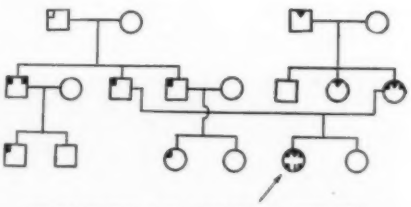
DENTAL CASTS SHOWING ABSENCE OF TEETH
Figure 2

The two casts at the top of the figure are of upper jaws which illustrate variations in expression of the missing-tooth gene, and are of persons not related to the propositus. In these casts the arrows at *A* and *C* indicate the position of missing incisors; *B* the presence of a peg-shaped incisor. The two casts at the bottom of the figure are of the jaws of the propositus. In these casts arrows at *D* and *E* indicate the position of missing lateral incisors in the upper jaw. The median frenum or space between central incisors is evident in this cast. Arrows at *F* and *H* indicate the position of missing lower bicuspids and that at *G* a rudimentary lower left central incisor. Where a tendency to missing teeth is inherited from both sides of the family, the effect seems to be cumulative as in the propositus.

ABSENCE of upper lateral incisors, especially the upper right lateral, occurs frequently in man. Its causation is most often attributed to malnutrition, thumb-sucking, mouth-breathing or venereal disease. In Figure 2*A-C* are shown photographs of two dental casts in which *A* indicates the position of a missing upper right lateral incisor; *B* indicates a peg-shaped upper right lateral incisor, which may be regarded as a

lesser manifestation of the same abnormality and *C* indicates a missing upper left lateral incisor. There is no indication that heredity is involved in some cases, but familial occurrence of similar abnormalities has been observed in other cases, one of which will presently be described. In the case of inherited anodontia the absence of lateral incisors has doubtless arisen by mutation. It is apparently transmitted as an irregular dominant character.

Seldom is it possible to study the results of matings in which both parents possess the character, as is the case in the family which we here report. The accompanying pedigree shows the blood relationships of seven persons who lack one or more lateral incisors and of one who had a rudimentary lateral incisor. Three had a large frenum. The propositus is indicated in the pedigree chart by an arrow. The two photographs of dental casts shown in Figure 2*D-H* make clear the condition of her teeth. She had a large frenum, lacked both upper lateral incisors (indicated at *D* and *E*), lacked a lower bicuspid on each side (indicated at *F* and *H*), and had a peg-shaped lower left central incisor (indicated at *G*). Her mother lacked both upper lateral incisors and had a frenum. The mother's sister and father had the frenum also. The father of the propositus lacked the upper right lateral incisor, as did also one of the father's brothers, his niece and his nephew. Another brother of the father lacked both upper lateral incisors and his father had a rudimentary upper right lateral incisor.



PEDIGREE OF MISSING TEETH

Figure 3

The location of a missing or underdeveloped incisor is indicated by black squares and the presence of a median frenum (wide space between the upper central incisors) is represented by a triangle. The propositus, who is indicated by an arrow, perhaps shows the effects of the gene in homozygous state, as her teeth exhibit greater defects than are found among her relatives. Her sister is an infant still too young for direct diagnosis.

It would appear from an examination of this family that a gene for missing lateral incisors can in the heterozygous state produce a peg tooth or can remove one or both upper laterals. It would also appear that more extreme consequences attend the presence of the gene in homozygous state, as is probably the case in the propositus, who lacks four permanent teeth and has an underdeveloped fifth.

◆

The Study of the Constitution

AS compared with the first edition, seven years ago, this book* has been increased 50 per cent in size. While it contains a great deal of interesting (though undocumented) material, it is still badly organized; and although an index has been added, there is nothing like an adequate bibliography. It emphasizes "human mutations," and its list of nearly 400 supposedly inherited anomalies in man is worth examining. PAUL POPENOE.

*NAEGELI, O., *Allgemeine Konstitutionslehre in naturwissenchaftlicher und medizinischer Betrachtung.* 2nd edition. Rn 16.20. Julius Springer, Berlin, 1934.

THREE GENES LOCATED IN THE 21 · 22 CHROMOSOME OF THE JIMSON WEED

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IN the present article a short description will be given of three types which were obtained from wild material of the Jimson weed (*Datura stramonium*). These types have been named "slender capsules," "Baltimore bad" pollen and "pale-1". The latter has also appeared spontaneously in controlled cultures. The three form a group by themselves in that they are due to recessive genes which have been located in the 21·22 chromosome by the method of trisomic ratios. This is the next to the smallest chromosome in this species and is the one which, when present as an extra, produces the "Globe" $2n + 1$ type, so called from its globose capsules (Figure 5). The 12 different kinds of chromosomes in Datura are sometimes represented by dominoes with numbered ends. Thus the "Globe" type would have the formula $2n + 21{\cdot}22$.

Slender Capsules

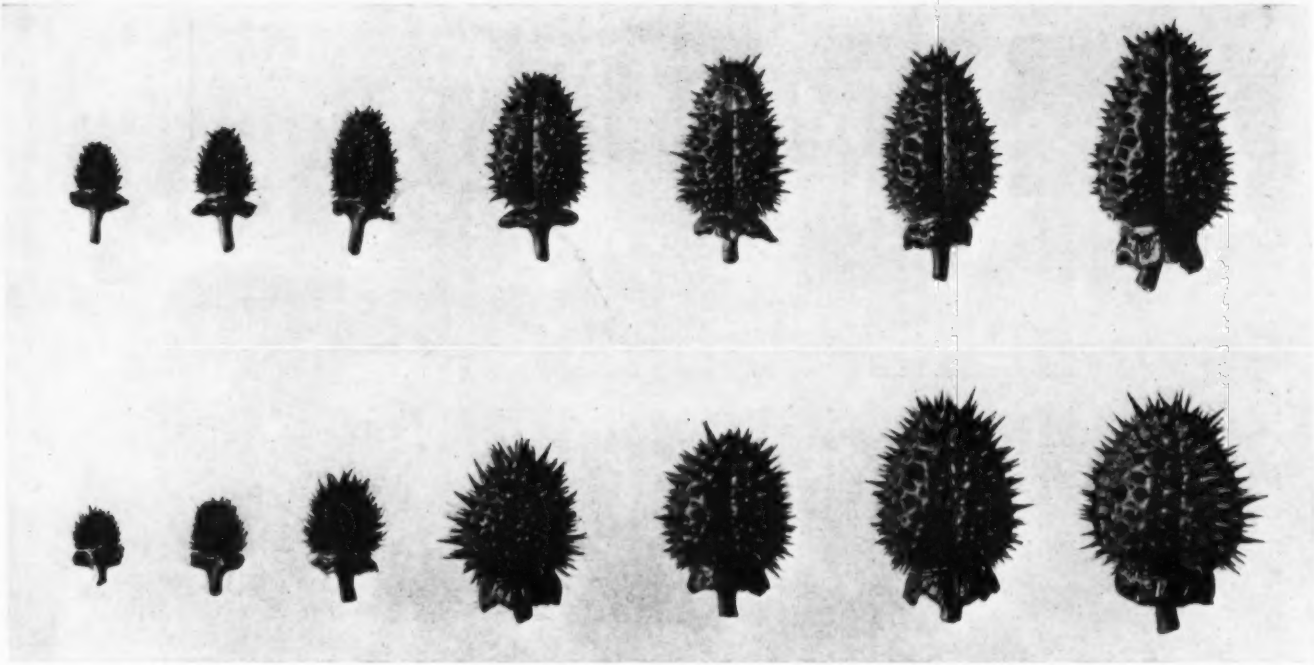
The character, "slender capsules" (*sc*) was discovered in a single plant in the fall of 1926.* The gene responsible for the character is a simple recessive. Only a single individual with slender capsules was found among a considerable number of normal Jimson weeds, although a careful search was made for others. Capsules of 53 of the nearby plants were opened at that time in a routine examination to disclose possible cases of ovule abortion. In 1933 the locus was revisited but no plants with slender capsules were found in the colony. Incidentally capsules of 50 plants were examined for ovule abortion. Three plants of the 1926 colony and 11 of the 1933 colony were homozygous normals since their offspring failed to segregate for "slender capsules." Since the type has been found only once, despite its distinctive appearance and the fact that a large number of wild Daturas both in Virginia and elsewhere have been inspected for possible variations, it is not impossible that the mutation we are discussing has occurred only this once.

The name, "slender capsules," was taken from the shape of the fruits. These are shown in Figure 4 in comparison with capsules of comparable ages from a normal control. It will be seen that even the youngest capsules are distinctly more slender than those of normals at the same stage of development. The shape of the capsules is not the only feature of the plant affected by the mutant gene. The leaves are narrower and their edges more strongly indented than those of normals. The buds are slender and the calyx is long and twisted. The leaf characters are less well expressed in the potted plant shown in Figure 6 than in field grown individuals which have distinctly "ragged" leaves.

Trisomic Ratios

It may be remembered that the ratios in disomic inheritance, in which two chromosomes are involved in the set carrying the gene in question, are different from the ratios in trisomic inheritance,[3] in which three chromosomes are similarly involved. If all the 12 primary $2n + 1$ types are rendered heterozygous for the gene, eleven of them should give disomic ratios in their offspring, while one of them should throw trisomic ratios. This last $2n + 1$ type

*This plant was located about 9.1 miles north of Bollingsbrook St., Petersburg, Va., and 13.7 miles south of East Broad St., Richmond, and near the home of Winston Lewis on the east side of the highway.



"SLENDER" AND NORMAL CAPSULES

Figure 4

Above, capsules of seven different ages from the type of Jimson weed called "slender capsules." Below, capsules of similar age from a normal plant. Notice that the slender capsules can be distinguished from normal capsules at all stages of development. The factor for slender capsules has been located in the 21-22 chromosome by the method of trisomic ratios.

THE "GLOBE" $2n + 1$ TYPE OF JIMSON WEED

Figure 5

The name "Globe" is derived from the globose shape of its capsules, as shown in different stages of development in the photograph. For comparison with the egg-shaped capsules of a normal Jimson weed, see lower row of fruits in Figure 4. The Globe type is also called $2n + 21 \cdot 22$ since it has the $21 \cdot 22$ chromosome as an extra. It is this chromosome which contains the locus for the factors responsible for the three characters:—slender capsules, Baltimore bad pollen, and pale leaves, described in the accompanying article.

then is judged to carry the locus of the gene in its extra chromosome. In disomic inheritance we get the familiar 3:1 ratios from selfing and 1:1 ratios from backcrossing. In trisomic inheritance, however, the ratios are quite different. The exact proportions depend upon whether there are one or two chromosomes carrying the gene. If a $2n + 1$ parent is simplex for a gene a, the formula for which may be written A_2a, the ratios from backcrossing will be $2A$:$1a$ among the $2n$ offspring and $3A$ to $0a$ among the $2n + 1$ offspring, provided there has been no crossing over. The ratios from selfing such a parent will be $8A$:$1a$ among the $2n$ offspring and $9A$ to $0a$ among the $2n + 1$ offspring. The ratios from backcrossing a duplex or Aa_2 parent are $1A$:$2a$ among $2n$ offspring and $2A$:$1a$ among $2n + 1$ offspring. The ratios from selfing a duplex parent are $5A$:$4a$ among $2n$ offspring and $7A$:$2a$ among $2n + 1$ offspring. It should be further stated that from male backcrosses (in which a heterozygous $2n + 1$ plant is used as a pollen parent) ordinarily no $2n + 1$ individuals are to be expected.

With this preliminary information about disomic and trisomic ratios let us see what has been learned from the breeding records as to which of the 12 chromosomes of Datura contains the locus for the gene for slender capsules.

Location of Gene for "Slender Capsules"

The primary $2n + 1$ types shown in Table I were obtained in the heterozygous condition by crossing a triploid ($3n$) by a slender capsule diploid ($2n$). These types with single extra chromosomes were then either male or female backcrossed to the slender capsule form and gave rise to offspring which segregated as shown in the table. No backcrosses were secured with the $2n + 19 \cdot 20$ type since, as is often the case, no plants of this type appeared among those resulting from the $3n \times 2n$ cross. Since the leaf characters of slender capsules are partially dominant, it was necessary to depend upon the capsules alone in recording. For this reason some of the late flowering $2n + 1$ types were not recorded for capsule shape. From an inspection of the table, it will be seen that all of the heterozygous $2n + 1$ types when backcrossed threw a reasonably close approximation to the expected 1:1 disomic ratios except the $2n + 21 \cdot 22$ type which showed trisomic 2:1 ratios. The tentative conclusion was reached, therefore, that the gene for slender capsules is located in the $21 \cdot 22$ chromosome.

To test this conclusion further, five

$2n + 21 \cdot 22$ plants in the F_1 backcross were again backcrossed to slender capsules. Four of these parents produced more slender capsule plants than normals in their offspring and were judged to be duplex ($Scsc_2$) for the gene. One was apparently simplex (Sc_2sc), since it gave 49 *Sc* to 29 *sc* individuals among the diploid ($2n$) offspring and 31 *Sc* to 6 *sc* among the $2n + 21 \cdot 22$ offspring, with several of the latter unrecorded. The calculated numbers of duplex and simplex individuals among five plants from an F_1 backcross are 3.3 and 1.7 respectively. The numbers 4 and 1 actually obtained are close to expectation for such small numbers.

Table II is a summary of the segregation from $2n + 1$ types. First are given totals from the extra chromosomal types of Table I, exclusive of $2n + 21 \cdot 22$. The proportions are reasonably close to the 1:1 ratio of disomic inheritance. Table II also gives a summary of the segregation from simplex and duplex $2n + 21 \cdot 22$ parents from the first and second backcrosses combined. Simplex parents (Sc_2sc), when backcrossed, obviously give 2:1 ratios among the $2n$ offspring while duplex parents ($Scsc_2$) give a reversed or 1:2 ratio. These are trisomic ratios and amply justify the conclusion that the gene (*sc*) for slender capsules is located in the $21 \cdot 22$ chromosome. The actual records come so close to the calculated figures as to raise a possible suspicion in the mind of the reader that some undue influence was exerted by the recorders. It was only in summarizing the data, however, that it was realized that the three ratios each departed from the calculated figure by less than one. With this apology for the ratios among the normals, we may turn to the ratios among the $2n + 21 \cdot 22$ offspring. The lack of slender capsules among the $2n + 21 \cdot 22$ plants from $Scsc_2$ backcrosses is not significant in view of the small numbers. Undoubtedly they would have appeared if the 52 other $2n + 21 \cdot 22$ plants in these backcrosses had been recorded. The presence of slender capsules among the $2n + 21 \cdot 22$ plants in the offspring of female backcrosses from Sc_2sc parents, when none is expected from the formula, is probably due to crossing over in the six strand stage which appears to be the explanation of similar exceptions in other cases.

"Baltimore Bad" Pollen

The condition of pollen called "Baltimore bad" is due to a recessive gene (*bd*) which when homozygous causes a high percentage of the pollen grains to abort and the rest to be of larger size than normal. The seed which gave rise to the first culture which segregated for "Baltimore bad" was collected in the fall of 1926 from one of two plants growing on dumps on the outskirts of Baltimore (near the end of Ridgley Street and the beginning of Annapolis Boulevard). One of these plants was apparently heterozygous for the gene *bd* since its offspring the following winter segregated for "Baltimore bads." Seed collected from the other plant from the same locality produced only normals. The symbol *bd*, used to designate the gene responsible for the pollen peculiarity, may be considered to be an abbreviation of the word "bad," or the initials of the two words, Baltimore dumps, where the type was discovered. We shall speak of the character as "Baltimore bad" although avoiding the alliterative symbols suggested by the initials of these words.

Characteristics of "Baltimore Bad"

The chief characteristic of plants homozygous for Baltimore bad is the condition of the pollen. There is an unusually large proportion of aborted grains, generally around 90 per cent but ranging from 75 to 100 per cent. The good grains vary in size but most of them are as large as pollen grains of tetraploids ($4n$). Figure 7 shows pollen from a Baltimore bad flower, alongside of pollen from a normal diploid ($2n$) and pollen from a tetraploid ($4n$) for comparison.

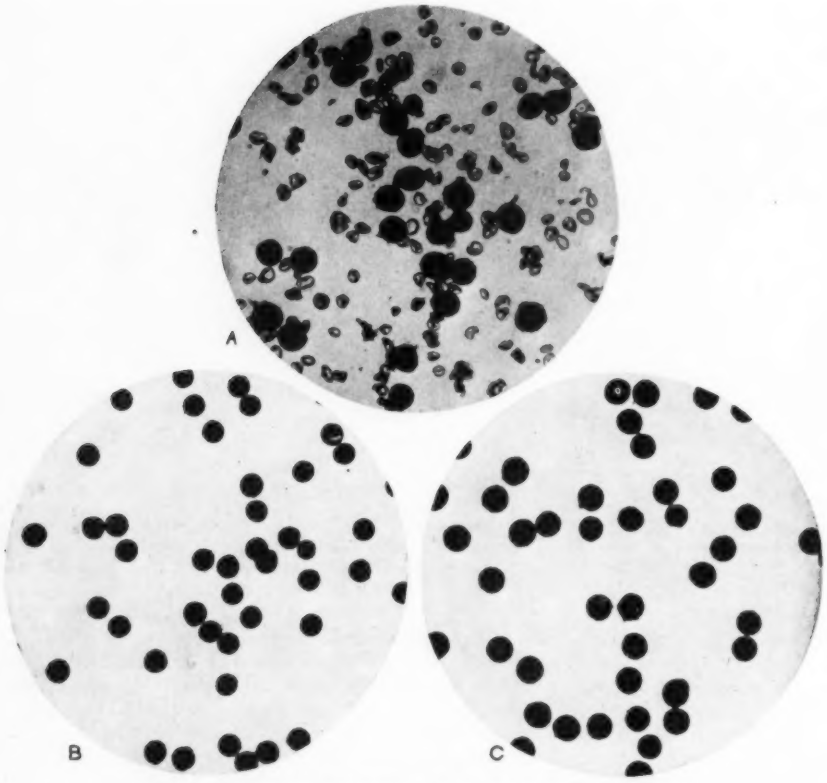
The condition of pollen, and presumably a similar condition in the egg cells, are responsible for sterility of

"SLENDER" PLANT COMPARED WITH NORMALS

Figure 6

Photograph of a slender capsule Jimson weed plant on right and of a normal control on left. Note the slender capsule of the type on the right in comparison with the larger egg-shaped capsules of the normal. The leaves of the slender capsule plant are narrower and more ragged than those of the normal. The flowers, which show poorly in a photograph against a light background, are long and slender. The factor for slender capsules thus influences the appearance of other parts of the plant, as well as the capsules.

Baltimore bad plants. In all our experience we have never obtained a viable seed from selfing, or from attempted crosses when using pollen from a diploid or from a tetraploid. The latter pollination one could not expect to be successful, whatever the condition of the egg cells since, as Buchholz has shown,[5] the $2n$ grains of a tetraploid regularly burst in the style of a diploid. Pollen of Baltimore bads has induced the formation of a few viable seeds when applied to the stigma of a tetraploid. This fact, as well as the size of the large grains, is evidence that the type produces some pollen grains with $2n$ or twice the normal number of chromosomes. The chromosomal behavior of Baltimore bads, which is responsible for the condition of the pollen, is discussed in an article in press in another publication[1] and need not concern us here. It is necessary only to mention some of the further visible consequences of the abnormalities in the pollen and egg cells. Figure 8 shows a Baltimore bad potted plant alongside of a normal control. The latter has set large capsules and unless shifted to a larger pot will not continue flowering. A small capsule can be seen on the Baltimore bad plant and at times somewhat larger ones are formed but they contain only abortive ovules. Our first records in segregating pedigrees were made from an examination of the pollen. Later it was found more convenient to take records in the field late in the season when the Baltimore bads were easily recognized by inspection on account of their lack of good capsules and their continued flowering. Figure 9 shows a normal and a Baltimore bad plant from the same pedigree culture photographed in the fall. The normal on the left is set up with capsules, as were most of the other plants in the field, while the Baltimore bad plant on the right has no capsules and is still flowering in abundance, despite the lateness of the season. Aside from the peculiarities connected with inability to set capsules, there is no apparent difference in appearance between Baltimore bad plants and normals.



POLLEN FROM NORMAL AND MUTANT FORMS

Figure 7

Photomicrographs of pollen magnified to the same scale: (*A*) from a "Baltimore bad" (*bd*) plant; (*B*) from a diploid (2*n*) plant; (*C*) from a tetraploid (4*n*) plant. Notice the high percentage of aborted or empty grains in the "Baltimore bad" pollen and the variation in size of the full grains (which photograph dark). Most of the latter are as large as the grains of a tetraploid (4*n*), and some are even larger. "Baltimore bad" pollen is due to a recessive gene which causes abnormalities in the behavior of all the chromosomes in the formation of the sex cells. This gene has been located in the Globe or 21·22 chromosome by the method of trisomic ratios.

Location of Gene for "Baltimore Bad"

The gene for Baltimore bad (*bd*) was located in the 21•22 chromosome by trisomic ratios in the same way as was the gene for slender capsules. The method of getting the $2n + 1$ types heterozygous, however, was somewhat more tedious. Since homozygous Baltimore bads cannot be used in crosses with triploids, it was necessary in making the cross $3n \times 2n$ to use a heterozygous individual of the constitution *Bdbd* as pollen parent. As a preliminary it was necessary, however, to identify such a heterozygous individual by securing selfed offspring from a number of normal individuals from a segregating pedigree culture. When a heterozygous plant was thus identified, it was continued by grafting and used as pollen parent in the cross to tri-

ploid. The trouble was not yet over, since only half of the $2n+1$ plants which resulted from this cross were heterozygous. In consequence it was necessary to sow selfs from several of each chromosomal type in order to secure the segregating progenies shown in Table III. As it was, we failed to get heterozygous plants of two of the types ($2n+7\cdot8$ and $2n+19\cdot20$).

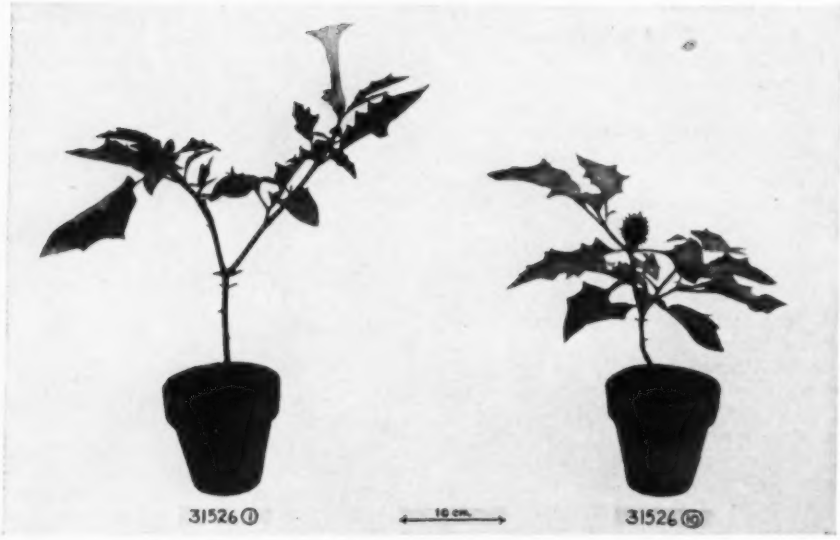
All of the trisomic types with records in Table III threw the disomic 3:1 ratio, or even a larger proportion of recessives, except the type $2n+21\cdot22$ which gave a close approach to the trisomic ratio, 8:1, among its $2n$ offspring. The tentative conclusion was reached that the locus of *bd* is in the $21\cdot22$ chromosome. Confirmation of this conclusion is given by the further ratios in Table IV. The totals of *bd* individuals in the offspring from selfing the $2n+1$ types, except $2n+21\cdot22$, are even higher than one would expect from a disomic 3:1 ratio. The $2n+21\cdot22$ types in this table are from F_2 or later generations except for the inclusion of the F_1's from Table III to make up the total for Bd_2bd parents. The $2n+21\cdot22$ types were considered to have the constitution Bd_2bd if their $2n$ progeny had considerably more normals than in a 3:1 ratio, and were considered to have the constitution $Bdbd_2$ if the normals and recessives in the $2n$ offspring approached a 1:1 ratio. It is evident that two types of trisomic ratios are obtained from $2n+21\cdot22$ parents, each of which departs widely from the ratios from other $2n+1$ types. The exceptional *bd* individuals among the $2n+21\cdot22$ offspring of Bd_2bd parents are probably due to crossing over as were the similar exceptions in the inheritance of slender capsules.

It was possible to classify the genotypes within segregating fraternities by testing some of their offspring. Thus out of 18 different $2n+21\cdot22$ plants tested in the progeny of Bd_2bd parents, 7 were Bd_3, 10 Bd_2bd and 1 $Bdbd_2$. The calculated values for this number are 4, 10 and 4. Of 14 different $2n+21\cdot22$ plants tested from $Bdbd_2$ parents, 6 were Bd_2bd and 8 were $Bdbd_2$. The calculated values are 4 and 10 respectively. These figures are in reasonable agreement with expectation for such small numbers. All in all, the evidence in hand seems amply to justify the conclusion that the gene for Baltimore bad pollen is located in the $21\cdot22$ chromosome.

"Pale-1"

Chlorophyll deficiencies of various kinds form one of the commonest classes of mutants in Datura as in other plants. For convenience the term pale has been applied only to types which can survive through the seedling stage. They have appeared as spontaneous mutants in our cultures, have been secured from nature and are relatively common induced mutants following radiation treatment. Pales vary in the apparent amount of chlorophyll which they contain, from types which are distinct in the seed pan to those which can be distinguished from normals only under the most favorable conditions of growth and external environment.

"Pale-1" is due to a recessive gene (*pl*-1) which was obtained from seed collected in Angol, Chile, in the spring of 1925. With the assistance of Mr. D. S. Bullock, head of the Mission School in Angol, a considerable territory around the school was searched for Daturas and seeds were collected from plants in 8 different loci. Two of the plants from Locus II must have been homozygous for pale since their offspring were all pale. Seeds were collected from two other plants from the same locus. Both turned out to be heterozygous since their offspring segregated for pales and normals. All the plants tested (9 in number) from the other 7 loci were homozygous normals and gave in their progeny only plants with normal green color. The mutation to pale must have occurred and the mutant become established in Locus II, some time before our collection of seed, since the gene was present in all the plants tested from this locus. Other



"BALTIMORE BAD" PLANTS BEAR NO CAPSULES
Figure 8

Photograph of a "Baltimore bad" Jimson weed on the left and a normal control on right. The normal plant has set a large capsule and has ceased flowering. The "Baltimore bad" plant has three small capsules which contained no good seeds but only aborted ovules. It was in flower at the time the photograph was taken and, because seed production made no drain upon its vigor of growth, it continued flowering until discarded. Inability to set seed is due to abnormality of pollen and egg cells.

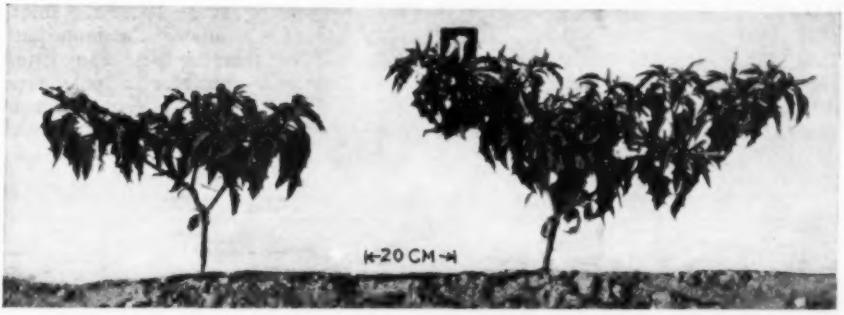
than this single patch in Angol, the type is not known to occur in nature. The same gene mutation, however, has occurred spontaneously in our cultures in unrelated stock, as will be shown later.

In appearance, pale-1 differs from normals in the paler color of its leaves and especially of its stems, which shows best when the plants are growing vigorously. Field grown plants late in the season or pot grown plants in the greenhouse are often difficult to record for color.

Location of Gene for "Pale-1"

Table V shows segregation in offspring of $2n + 1$ types which were obtained in the heterozygous condition by crossing a triploid ($3n$) by a pale diploid ($2n$). Except for $2n + 19 \cdot 20$, all the $2n + 1$ types are represented by male backcrosses in the table and for these the actual ratios observed are given alongside of the significance of their deviations from a 1:1 ratio expected in disomic inheritance. It will be observed that the ratios in male backcrosses of both the $2n + 11 \cdot 12$ and the $2n + 21 \cdot 22$ types deviate greatly from 1:1 ratios, the deviation for the first being 5.14 and for the second 6.91 times the probable error. They could both pass better for 2:1 ratios expected in trisomic inheritance. The deviation of the $2n + 11 \cdot 12$ ratio from 2:1 is 2.69 times the probable error and that of the $2n + 21 \cdot 22$ ratios is 1.95. These ratios in male backcrosses would seem to locate the gene *pl*-1 in two different chromosomes rather than in a single one.

A number of lines of evidence, however, indicate that the gene *pl*-1 has its locus in the $21 \cdot 22$ chromosome only. In the first place a presumption would



INDETERMINATE FLOWERING HABIT OF "BALTIMORE BAD" PLANTS

Figure 9

Two field grown Jimson weeds from a segregating progeny. The normal control at left has a full crop of capsules and has ceased flowering. The "Baltimore bad" plant at right is larger, has no normal capsules and is flowering abundantly despite the lateness of the season. Flowers show poorly in the photograph except in front of the black square. This photograph shows the stage at which "Baltimore bad" plants are recorded by their abundant flowers and lack of good capsules.

favor this chromosome, since the ratio from parents with it as the extra departs further from a 1:1 ratio than does the ratio when the parent had the 11•12 chromosome extra. Furthermore, this presumption is strengthened by the ratios in the female backcrosses which are clearly trisomic for $2n+$ 21•22 but approach more nearly disomic ratios for $2n+11$•12. Later a peculiarity was discovered regarding the pale race from Chile which was responsible for the abnormal ratios from $2n+$ 11•12 parents. It was found to be a cryptic chromosomal type in which the 11•12 and the 21•22 chromosomes had interchanged segments to form the chromosomes 11•21 and 12•22. This cryptic type (PT3) is one of a considerable number of races with chromosomes modified by segmental interchanges discussed in a recent publication[6] under the term Prime Types. The first one of them discovered, the "B" prime type, has been discussed in an earlier number of the JOURNAL OF HEREDITY[2] where it is shown that two instead of only one of the twelve $2n+1$ types should produce more normals in their offspring than would be expected in disomic inheritance if the gene was in one of the interchanged chromosomes. This has been found to be the case, not only for the *B* prime type which carries the gene for white flowers and for PT 3 which carries the gene for pale-1, but also for another prime type with interchanged chromosomes one of which carries the gene for "zigzag." The linkage between the gene *pl*-1 and both the chromosomes 11•12 and 21•22 in hybrids with PT 3 is further shown by the condition of pollen. PT 3 induces about 25 per cent aborted pollen grains in hybrids with our standard race. When hybrids between our standard and a pale PT 3 were backcrossed to pale PT 3, most of the pale offspring had good pollen and most of the plants with normal green color had 25 per cent bad pollen, showing that the gene is linked with chromosomes responsible for the bad pollen, in this case with the chromosomes 11•12, 21•22 and the interchanged chromosomes 11•21 and 12•22. A fuller discussion of the types of ratios when prime types are involved will be deferred to a later publication.

Same Pale Originates Under Observation

It is not necessary to depend for the location of *pl*-1 alone upon the evidence presented in the preceding para-

graphs, since a mutation to the same gene has occurred within our standard Line 1 and trisomic ratios have been secured free from interference with other prime types. Our first haploid plant, 20745(4), has been kept growing by grafting since 1921. A single plant, 2501(34), among the immediate offspring of this haploid, was found to be heterozygous for a pale type named pale-3 which segregated out in the F_2 generation. Although it was

TABLE I. Segregation of "slender capsules" (se) from heterozygous Zm•1 parents.

Heterozygous Zm•1 parent	Offspring from Female Back-crosses				Offspring from Male Back-crosses	
	Zm		Zm•1		Zm	
	Se	se	Se	se	Se	se
Zm•1•2 (R1)					45	37
Zm•3•4 (Ge)	34	29	*	*	33	29
Zm•5•6 (Rx)					42	38
Zm•7•8 (Y1)					34	35
Zm•9•10 (Ro)	22	25	9	14		
Zm•11•12 (Ck)	32	23	21	14	41	31
Zm•13•14 (Mo)					39	30
Zm•15•16 (R4)					24	35
Zm•17•18 (Pa)					29	41
Zm•19•20 (Sp)					—	—
Zm•21•22 (G1)	46	19	22*	5*	36	30
Zm•23•24 (Ix)					22	15

* None or only part of the Zm•1 types were recorded for capsule shape.

TABLE II. Summary of segregation of "slender capsules" (se) from heterozygous Zm•1 parents.

Genotypes of Parents		Offspring from Female Back-crosses				Offspring from Male Back-crosses	
		Zm		Zm•1		Zm	
		Se	se	Se	se	Se	se
Totals from Zm•1 types except Zm•21•22							
Sese X sese & reciprocal (12 parents tested)	Ratio	1	1	1	1	1	1
	Observed	68	77	80*	29*	312	299
	Calculated	68.5	68.5	30	30	303.5	303.5
Totals from Zm•21•22 type only							
Sese X sese & reciprocal (3 parents tested)	Ratio	2	1	3	0	2	1
	Observed	95	48	65*	11*	56	20
	Calculated	95.3	47.7	74	0	58.7	29.3
Sese X sese (4 parents tested)	Ratio	1	2	2	1	1	2
	Observed	61	121	0*	0*	-	-
	Calculated	60.7	121.3	4	2		

* Only part of the Zm•1 types were recorded for capsule shape.

TABLE III. Segregation of "Baltimore bad" (bd) from heterozygous Zm•1 parents.

Heterozygous Zm•1 parent	No. of parents tested.	Offspring from selfing			
		Zm		Zm•1	
		Bd	bd	Bd	bd
Zm•1•2 (R1)	3	136	39	37	13
Zm•3•4 (Ge)	1	29	17	17	1
Zm•5•6 (Rx)	2	85	29	22*	10*
Zm•7•8 (Y1)	-				
Zm•9•10 (Ro)	4	133	53	70	22
Zm•11•12 (Ck)	3	152	59	53	14
Zm•13•14 (Mo)	4	159	64	52	34
Zm•15•16 (R4)	2	87	40	37	12
Zm•17•18 (Pa)	2	94	31	*	*
Zm•19•20 (Sp)	-				
Zm•21•22 (G1)	4	225	84	87	4
Zm•23•24 (Ix)	3	211	74	87*	31*

* None or only part of the Zm•1 types were recorded for "Baltimore bad".

TABLE IV. Summary of segregation of "Baltimore bad" (bd) from heterozygous Zm•1 parents.

Genotypes of Parents		Offspring from selfing			
		Zm		Zm•1	
		Bd	bd	Bd	bd
Totals from Zm•1 types except Zm•21•22					
Bdbd (86 parents tested)	Ratio	3	1	3	1
	Observed	1104	443	292*	139*
	Calculated	1161.8	387.3	299.6	133.2
Totals from Zm•21•22 type only					
Bdbd (20 parents tested)	Ratio	8	1	9	0
	Observed	988	111	310	9
	Calculated	974.9	122.1	319	0
Bdbd (9 parents tested)	Ratio	5	4	7	2
	Observed	515	284	150	52
	Calculated	332.8	266.2	157.1	44.9

* Only part of the Zm•1 types were recorded for "Baltimore bad."

TABLE V. Segregation of "pale-1" (pl-1) from heterozygous Zm•1 parents.

Heterozygous Zm•1 parent	Offspring from Female Back-crosses				Offspring from Male Back-crosses			
	Zm		Zm•1		Zm			P.E. (for 1:1)
	Pl	pl	Pl	pl	Pl	pl	Ratio	
Zm•1•2 (R1)					98	74	1.32:1	2.71
Zm•3•4 (Ge)					73	70	1.04:1	.37
Zm•5•6 (Rx)	49	44	27	14	86	78	1.10:1	.92
Zm•7•8 (Y1)					100	91	1.09:1	.94
Zm•9•10 (Ro)					96	87	1.10:1	.99
Zm•11•12 (Ck)	37	30	2	2	148	94	1.57:1	5.14
Zm•13•14 (Mo)					102	90	1.13:1	1.28
Zm•15•16 (R4)					69	78	.88:1	1.10
Zm•17•18 (Pa)					94	89	1.06:1	.68
Zm•19•20 (Sp)								
Zm•21•22 (G1)	25	42	6	1	77	57	2.65:1	6.71
Zm•23•24 (Ix)					83	73	1.14:1	1.89

TABLE VI. Segregation of "pale-3" (pl-3) from heterozygous Zm•1 parents.

Heterozygous Zm•1 parent	Offspring from Female Back-crosses				Offspring from Male Back-crosses	
	Zm		Zm•1		Zm	
	Pl	pl	Pl	pl	Pl	pl
Zm•1•2 (R1)	48	43	2	7	86	74
Zm•3•4 (Ge)	30	30	21	22	80	93
Zm•5•6 (Rx)	24	25	21	28		
Zm•7•8 (Y1)	31	41	3	3		
Zm•9•10 (Ro)	33	33	27	21	86	82
Zm•11•12 (Ck)	39	46	21	25	114	103
Zm•13•14 (Mo)	36	35	17	14	71	67
Zm•15•16 (R4)	25	35	25	11		
Zm•17•18 (Pa)	29	26	4	9	41	29
Zm•19•20 (Sp)					31	45
Zm•21•22 (G1)	93	77	39	2	129	99
Zm•23•24 (Ix)	31	36	23	13		

similar to pale-1 in its effect upon leaf color, there was no chance, apparently, of this new pale having come from pale-1 through accidental mixture of seed or some slip in records. The first pale-1 plants in our cultures had peculiarities of leaf, capsules and habit of growth characteristic of all the purple-flowered races from Chile and Peru which made it impossible to confuse them with our standard Line 1 from which pale-3 had arisen. Hybrids between the Chilean races and Line 1 are also readily distinguished from the latter by differences in appearance. The plant 2501(34), the offspring of which segregated for pale-3, was recorded as normal in appearance. Hence it could not have been an unsuspected hybrid with a pale-1 Chilean plant. Moreover, the segregating progeny in which pale-3 first appeared was grown in the greenhouse in the winter of 1926-27 and at that time pale-1 had not been purified and rendered similar to Line 1 in external characters by backcrossing and selfing.

The *pl*-3 was crossed onto triploid and the resulting heterozygous $2n + 1$ types were tested by backcrosses, with results shown in Table VI. All of the $2n + 1$ types are seen to give disomic ratios, except $2n + 21 \cdot 22$. This type gives an approach to the trisomic ratios expected, on the assumption that the gene is located in the extra $21 \cdot 22$ chromosome. The ratios among the diploid ($2n$) progeny of the female backcross depart widely from the calculated values, but this fact is balanced by the ratios from duplex ($Plpl_2$) parents shown in Table VII. This is a summary table and gives a tabulation for the $2n + 11 \cdot 12$ and the $2n + 21 \cdot 22$ types separately from the other $2n + 1$ types. The evidence is reasonably clear that the $2n + 21 \cdot 22$ type alone throws trisomic ratios and that this extra chromosome therefore contains the locus for *pl*-3. The $2n + 11 \cdot 12$ type in this case throws reasonably good disomic ratios and not an approach to trisomic ratios found when heterozygous for pale-1 and Prime Type 3. Reversed trisomic ratios from $Plpl_2$ backcrossed parents, shown also in Table VII, confirm this placing of *pl*-3 in chromosome $21 \cdot 22$.

The two pales having been located in the same chromosome, they were crossed together to see if they were identical. The 17 offspring of this cross were all pale. We may conclude, therefore, that the gene responsible for the pale type discovered in a Chilean race in South America is the same as the gene which arose from an independent mutation in a Line 1 haploid.[4]

TABLE VII. Summary of segregation of "pale-3" (pl-3) from heterozygous Bn-1 parents.

Genotype of Parents		Offspring from Female Back-crosses				Offspring from Male Back-crosses	
		Bn		Bn-1		Bn	
		P1	p1	P1	p1	P1	p1
Totals from Bn-1 types excluding Bn-11-12 and Bn-21-22.							
Plpl x pl, & reciprocal (10 parents tested)	Ratio	1	1	1	1	1	1
	Observed	510	489	140	128	285	249
	Calculated	499.5	499.5	133.5	133.5	277.5	277.5
Totals from Bn-11-12 only							
Plpl x pl, & reciprocal (2 parents tested)	Ratio	1	1	1	1	1	1
	Observed	39	49	25	15	114	108
	Calculated	44.0	44.0	24.0	26.0	108.0	108.0
Totals from Bn-21-22 only							
Plpl x pl, & reciprocal (5 parents tested)	Ratio	1	1	1	0	1	1
	Observed	59	77	28	4	132	92
	Calculated	148.7	57.3	43	0	150	94
Plpl$_2$ x pl, & reciprocal (3 parents tested)	Ratio	1	0	0	1	1	0
	Observed	99	117	41	37	95	147
	Calculated	55.3	110.7	46.3	32.7	66.3	132.7

A second pale-3 was found in the progeny of a plant of Line 1 which had been crossed with a pale-1 Chilean plant. This second pale-3 was found in the progeny of a plant which had been crossed with a pale-1 Chilean plant. This second pale-3 was found in the progeny of a plant which had been crossed with a pale-1 Chilean plant.

Conclusion

The records which have been given for three genes show the significance of trisomic ratios as a means of locating factors in particular chromosomes. Certain exceptions affecting the ratios among the $2n + 1$ progeny which are probably due to crossing over, and apparent trisomic ratios from two $2n + 1$ types instead of from only one, when the gene is brought in by a prime type with interchanged chromosomes involving the locus in question, will be discussed in more detail in a later publication. They offer no serious hindrance to the use of the trisomic method of locating genes in particular chromosomes. The $21 \cdot 22$ chromosome is one of the two chromosomes which has no secondary $2n + 1$ type in which one half is doubled as an extra. It has not been possible, therefore, to use sec-

ondary trisomic ratios to locate these three genes in their proper half chromosome as has been done with three genes in the 17•18 chromosome. It may be possible, however, by ratios from such tertiary $2n+1$ types as $2n+11{\cdot}21$ and $2n+12{\cdot}22$, as well as by linkages between the three genes themselves, to gain definite information regarding their linear distribution in the 21•22 chromosome in which we have learned they are located.

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✦

Origin of Domesticated Animals

THIS book* contains the transactions of the conference on the origin of domesticated animals, held at the Laboratory of Genetics of the Academy of Sciences, U. S. S. R., on March 23-25, 1932. The material is printed in Russian but contains English summaries of the more important papers. There is included a total of 15 papers which vary in nature from the extremely general discussions of the origin of domestic animals to the detailed accounts of osteological measurements and indices in their relation to systematic zoology.

The opening paper by Professor Vavilov gives a very good picture of the rôle of Soviet Science in studying the problems connected with the origin of domestic animals. Since the Soviet country with its extensive territory in Asia includes a number of regions where the main primary process of the formation of several important species is known to have taken place, it is proper that an intensive study of their origin should be centered there. Already considerable material pertaining to variation among domestic animals has been collected and it is planned that new museums shall be provided where scientifically trained men can study such material. To supplement this phase of the work there was established in 1931 the Hybridological Institute of the Soviet Union for the purpose of hybridization of remotely related forms on a large scale.

The more truly scientific papers present data upon the origin of domestic pigs, the fossil camels of the old world, structure of the metapodii of some wild and domestic animals and a very broad discussion of reindeer breeding. A large part of the data consist of measurements made upon bones in museum collections, although Havessan's paper on Aboriginal Pigs of Chuvashia deals with the live animals or material collected from existing herds.

Although the program outlined by the Congress contains many items which, if properly carried out, probably would yield information of scientific value, the whole program is so vast that there is some element of doubt whether it will work out as planned. Let us hope that our friends do not err by thinking that large quantities of raw material in the form of animals of various sorts plus the establishment of museums for the study of parts will answer all the questions concerned with the evolution of domestic animals. Evolution is a topic which cannot be handled with a five year plan.

H. C. McPhee
U. S. Department of Agriculture.

*"The Problem of the Origin of Domesticated Animals," Leningrad, 1933.

IRIS TWINS

ADOLPH E. WALLER
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IN the course of producing hybrid irises several thousands of seeds have been germinated each year for the last two or three years in the Botanic Garden at Ohio State University. Only once before was a case of twin seedlings suspected and that did not on examination prove definitely to have happened as the individuals could not be satisfactorily separated from a mass of crowded seedlings. It appears then that twinning is rather rare. Whether this pair is a two egg pair or a case of identical twins will have to wait for answer when the plants have matured and bloomed. It is expected that the difference if any will appear in the habits of growth and appearances of the flowers. The photograph shows clearly the close connection of the two plants and in the foreground are the remains of the single seed and the modified cotyledon which acts as an absorbing organ connecting the plumule and hypocotyl with the endosperm during germination and early growth stages. The plants are hybrid seedlings of the species *Chaemaerisis*, one of the dwarf irises of the bearded group frequently seen in gardens. Since rhizome division is the common means of propagating these irises, if these are identical twins, we have an example of precocious vegetative multiplication.

"SIAMESE" IRIS TWINS

Figure 10

This pair of closely joined plants of the dwarf bearded iris arose from a single seed. At present the twins seem much alike, but not until the plants flower will it be possible to decide whether they are "identical" or "fraternal" twins. This iris is normally propagated vegetatively, and identical twinning might be considered to be a precocious manifestation of the normal reproductive tendency of the species.

"Iarovization" Not New

SOMEWHAT over a year ago the Russian technique of iarovization received considerable notice in the columns of the JOURNAL. Since that time a number of publications have appeared which have discussed and attempted to evaluate the technique developed by Lysenko. Among these a

28-page bulletin issued by the Imperial Bureau of Plant Genetics gives the most extended discussion of the Russian literature of which we are aware. (WHYTE, R. O. and HUDSON, P. S. Vernalization or Lysenko's method for the pre-treatment of seed. *Imp. Bur. of Plant Genetics Bulletin*, Cambridge, 1933.) More recently the Bureau of Plant Industry of the U. S. Department of Agriculture has issued a fourteen page mimeographed circular on the subject which summarizes the possible value to the practical farmer of these methods of accelerating growth. (MARTIN, J. H., Iarovization in Field Practice. Mimeographed circular. No number or date, U. S. Department of Agriculture.) Both of these publications contain rather extensive references to the literature of the subject.

It is of interest that Dr. Martin finds that the history of the method of chilling germinated seed carries us back well over a century. "High temperature iarovization" (which appears to be quite a distinct process) has a history dating back to Roman times. It appears that in Great Britain about 1840 the late sowing of winter wheat was widely practised. This virtually constituted iarovization in the field as the wheat did not sprout until spring. In Tennessee about 1837 a crude form of iarovization was also rather widely practised and was considerably discussed in the agricultural publications of that time.

It is probable that the value of the technique to the Russian agriculturalists depends upon the peculiar climate conditions which make the early maturing of the crop a matter of great importance. In parts of the Russian wheat belt the transition from a moist spring climate to an arid summer climate is very sudden. If the wheat does not mature in time the crop is foredoomed to failure. It is concluded in Dr. Martin's report that the technique has little practical value for American agriculture and that its value for experimental plant breeding is somewhat limited, although it is conceded that it does have a place in this field.

Explanations of why prolonged chilling (or partial drying) of germinated seed of some plants has such a marked effect on subsequent growth habits are mostly speculative with dark hints of "growth enzemes," "time," and "total darkness" playing dubious roles. There is in iarovization a field of plant physiology still virtually unexplored, with genetics playing an important part, for there is little doubt that reactions to these stimuli are inherited characteristics. Perhaps the answer, when found, may prove to have scientific and practical applications yet not dreamed of, that will make two grains of wheat grow where one now is proving somewhat disconcerting to the newer non-crop agricultural economists.

A Brief for the Y-Chromosome

The Editor of the Journal of Heredity:

The article by Dr. T. D. A. Cockerell, "The Relative Ability of Men and Women," appearing in the April issue of the JOURNAL OF HEREDITY, is, as published, misleading. In order to give one a fair comparison of the intellectual ability of the male and female students attending the University of Colorado, Dr. Cockerell should have listed the studies of these students. One could then have considered the comparative mental capability of the men and the women in comparison with the subject studied. Speaking generally, the subjects studied by the average male college student are far more difficult than those taken by the female. Names of women who have attained nation-wide prominence in the

fields of engineering, the more difficult branches of chemistry, or any of the major sciences that require unusual brain concentration are almost entirely missing from the long list of those who have brought our scientific world to its present high efficiency. It is to be expected that women will excel in certain studies, but please give us, Dr. Cockerell, a comparison of the courses taken by your students.

The relative ability of men and women and the present and future position of woman in relation to our present-day unnatural form of living is a subject requiring thought and careful consideration. First, because through woman only, can our civilization endure. Second, because through the emancipation of woman our civilization seems doomed to destruction.

As I have lived among totally uncivilized races, as well as those partly civilized, I have had an unusually good opportunity to form from actual observation a comparison of the primitive stone age types, through different grades of culture, with our modern highly artificial women of today, who through higher education and their own initiative are rapidly taking the place of men in many lines of industry, and in some lines have almost completely monopolized work that but a few years ago was considered the exclusive field of men.

The position of the highly civilized woman of today in relation to man is of the greatest interest, for it has, and will have, overwhelming influence in the destiny of our race.

Today, most young women having a high school education who have reached the age of twenty and who are not married, or are not potential prostitutes, are looking for a job. A vast number of the present generation of young women feel there is something else in store for them except being human incubators. They wish to be free; to have a career; to be an individual, and do something. If they use sex at all, they wish to do so as impulsively and casually as does man. The tendency of the age is to remove the taboo of physical love from unmarried individuals, and to look upon it as an amusing game to be enjoyed at will. In this is shown a strong tendency to return to the customs of the primitive races, before they were corrupted by the teachings of civilization.

As I understand it, the present aim of the woman movement is to be entirely emancipated from man's dominance and to throw off, first, the unfair bonds and taboos that have been placed on her gradually by civilization. Second, to overcome the natural biological laws that have guided her destinies, from the beginning of the human race. Can she accomplish these two things? My answer is: Yes, to the first—completely. No, to the second—that is, only partially.

Undoubtedly, in the beginning all living organisms were bi-sexual, and each organism was therefore capable of reproduction. Through the ages the higher organisms have, by evolution, reached their present stage of perfection, one of which has been the complete separation of the sexes, until each sex has become an entire being unto itself. As evolution advanced the different species, it is probable that both male and female were at first equal both mentally and physically. The physical difference today is vast.

Biologically speaking, the position of the male is active, and of the female passive; for in all organisms, life begins through the approach of the sperm cell (male) towards the egg cell (female), and the entrance of the former into the latter. The further we advance in the animal and in the vegetable world from the lower to the higher forms, the more markedly are the male and female individuals distinguished from one another.

In what we term the human race, this is especially true; in humans and the higher species of mammals the males exhibit stronger evolutionary tendencies than the females owing to the fact

that their share in the duties of reproduction has become less important. The more extensive organic expenditure demanded of the female, by nature, in the reproductive functions has limited in many ways the female development; this expenditure in the human female having gone on for tens of thousands of years has gradually retarded her development, both bodily and mentally, while man during the same period, being free from the reproduction expenditure, has stored this energy to his own use, thereby creating a stronger body and greater brain. This natural condition working slowly and surely, since the beginning of the human race, has built up a vast difference between man and woman in both their mental and their physical make-up. Can woman change this condition? In part surely, but not entirely. By sacrificing many of her womanly qualities, she may evolve from herself a being which is a poor imitation of both man and woman.

It is not possible for woman to ensure the development she is striving for in the woman movement of today, without eliminating to a large extent her characteristics as a sexual being. I do not think that complete equality between man and woman in the near future is possible, because woman due to her limitations by nature is not fully developed, and if development comes, it will be very gradual, and at the expense of her natural sexual life.

Man, the male, is much nearer a perfect being than woman, the female. When analyzing man, you know where you are, you can come to an end, but with woman, there is always something to be expected. In other words, woman is a comma, man a full stop.

The struggle of the advanced thinking woman of today to attain an equality of position with man, who has oppressed and made a virtual slave of her from the beginning of civilization, appears to me from the purely human point of view, both courageous and interesting, and I believe that in the near future, woman will be entirely emancipated in all legal ways from man's dominance and be recognized as his mental equal. The cringing dominated woman, who relied on man for her every need, is rapidly disappearing, giving place to the self-reliant woman, a free personality.

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Prizes for Publications on Race

THE *Saturday Review* (Aug. 1934) has announced a prize of $1,000 established by Mrs. Edith Anisfield Wolf in memory of her father, to be called the John Anisfield Award. The prize will be awarded annually after August first of each year, to a sound and significant book published in the previous twelve months, on the subject of racial relations in the contemporary world. The prize will be administered by a committee of judges consisting of Henry Seidel Canby, Editor of *The Saturday Review of Literature;* Henry Pratt Fairchild, Professor of Sociology in New York University; and Donald Young, of the Social Science Research Council. Books submitted for the award may be sent to the Anisfield Award Commitee, care of *The Saturday Review,* 25 West 45th Street, New York City. The first award will be made to a book published between August 1, 1934 and August 1, 1935.

"SPORADIC FLIGHTLESS" FOWLS

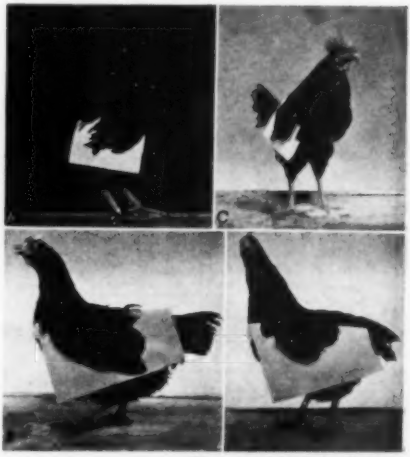
ROY L. MAYHEW
Louisiana Agricultural Experiment Station

TWO unusual birds have appeared among the chickens hatched from the flock of Rhode Island Reds belonging to the writer during the past five hatching seasons. All of the birds of the flock have been under the close observation and management of the author, having served as the principal source of hatching eggs for the Department of Parasitology of the Louisiana Experiment Station.

During the early fall of 1931 one of the pullets, No. 218, attracted attention because of the entire lack of flight feathers in both wings when she was eight months of age, the feathers having molted during the preceding month. This bird remained in this condition until her death at the age of two years and four months, passing through one molt at the end of her first laying year. Figure 11*C* shows this individual and 11*B* her full sister.

The following fall almost all the flight feathers were observed to be lacking in both wings of a cockeral No. 344, at the age of ten months, the feathers having been lost during the preceding two months. This bird was raised among the experimental chickens of the Department of Parasitology approximately one and one-half miles from where No. 218 was raised. Unfortunately, this bird was found to have been hatched from an unidentified egg from pullets of the author's flock, among which was No. 268, a full sister of No. 218. An examination of the wings of No. 344 showed a few small feathers present which appeared to be fight feathers of the juvenile plumage. Most of these were lost during the following six weeks and new ones did not take their place.

The source of the original stock of this flock was as follows: Nos. 7, 17 and 34 were purchased from a breeder in Massachusetts, and No. 1 from a breeder near Baton Rouge, Louisiana, who purchased the sire and dam in Mississippi. The six additional hens making up the original flock were purchased locally. It should be stated that No. 17 is the sire of No. 27 as well as No. 42, space being lacking in which to show this in the figure. No. 27 was hatched from an unidentified egg from one of the seven original hens of the flock.

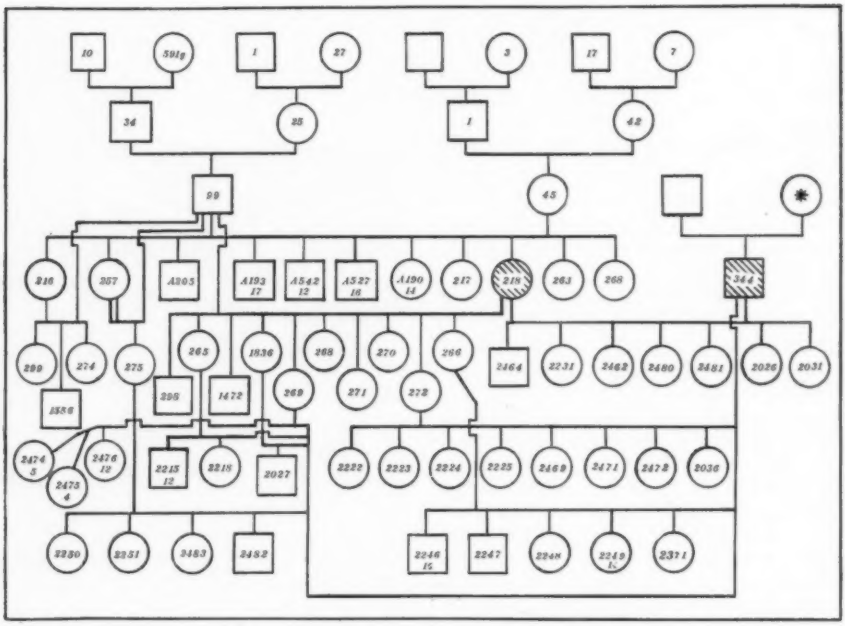


Photograph by John P. Gray

A NON-GENETIC "FLIGHTLESS"?
Figure 11

A, C—Two views of flightless rooster 344. *B*—Normal full sister of "flightless" hen 218, shown at *D*. These two "flightless" fowls appeared in related flocks, but the genetic nature of the deficiency has not been determined. Neither does it appear to be environmental, because it has only appeared in two individuals in flocks kept under uniform conditions.

It will be noted from Figure 12 that two special matings have been made in an attempt to determine the inheritance of the condition. The first one was made during the fall of 1931 and included No. 218 and several full sisters with No. 99, their sire. The second was made during the following



RELATIONSHIP OF THE "FLIGHTLESS" FOWLS

Figure 12

The parents of ♂ 344 were obtained from the flock in which ♀ 218 appeared, but the relationship is not known. Subsequent matings to establish the genetic nature of the defect have been negative. The numbers below the band number of the symbols indicate the age in weeks at which the observations of these individuals were ended.

season between the affected male, No. 344, No. 218 and her daughters which were sired by her sire as indicated in Figure 12. None of the chicks hatched from either of these matings and kept to the various ages indicated in Table I has shown any indication of losing flight feathers.

The results of the special matings indicate that the condition described is not inherited as a simple mendelian character and that if it is inherited, the mechanism is undetermined. The condition does not seem to be pathological, since no evidence of any inflamation or abnormality of the feather follicles or of the wing was observed.

In certain respects the condition described above resembles the dominant "flightless" described by Warren.* In flightless, however, the feathers break off and portions remain in the follicles.

TABLE I.—Summary of the Results of the Various Matings

Age at end of observations		Weeks			Months								Total
		6-12	12-20	20-38	10	11	12	13	14	16	19-24	26	
Dam	Sire												
45	99	4	4			2	3	2					15
218	99	7		8				1	1		3	2	22
Full sisters of 218	344	1		4				3					8
Daughters of 218 sired by 99	344		4	4.	2	4	2						16
218	344		2			4				2			8

*Warren, D. C. 1932. Flightless—A Heritable Variation in the Domestic Fowl. *Jour. Hered.* 23: 449-452..

GENES OF EMBRYOS AND OF MEN

Reviewing new books wherein Dr. Morgan speculates on a gene changing during development—Huxley and de Beer cover the same ground from a different angle—Whitney champions the sterilization of a quarter of the American Population—and Hitler's Germany is exposed to further preachments on the sins of omission of reproduction against the genes of the hypothetical Aryan Race.

A NEW CONCEPT OF THE GENE

FOR twenty-five years experimental embryology and genetics have been often in the biological limelight. Each field owes its present interest and recent advances to the adoption of new techniques of experiment which have been quite different in the two cases and have often seemed to be leading in different directions. The new facts and new viewpoints arising from each discipline have contained so much of general biological significance, that there has been much curiosity and not a little bewilderment among biologists as to how the theories of individual development were to be reconciled with the theories of genetics.

Now, as if in answer to this need for synthesis, appears a book with the arresting title which Professor Morgan is uniquely qualified to choose.* The author began his scientific work as an embryologist, later became interested in genetics and for many years has contributed significantly to both fields. It must be of interest to all biologists to learn from one who has ridden two such active steeds, how they are to be driven in tandem, and toward what goal they are going.

The book is written for the general student, and its emphasis is clearly upon descriptive embryology and upon some of the problems of experimental embryology. Wherever interrelations between embryology and genetics are apparent, these are pointed out, but no attempt is made to formulate a general theory. One gathers that Professor Morgan believes the time for this has not yet come. He prefers, as in his other books, to expose the facts and only occasionally to discuss their implications.

After a brief and clear description of the development of the animal through gastrulation, the behavior of half and whole embryos and of egg fragments is described and the conclusion reached that development is "not dependent upon a strict prelocalization of organ-forming materials in the egg as a whole." Short chapters are devoted to the development of a single embryo from two eggs and to twins and twinning. The discussion of multiple chromosome types which follows introduces the first direct allusion to the effects of the genes, since the chief developmental interest centers in the idea of genic balance which is briefly described. Under the chapter heading "Protoplasm and Genes" (protoplasm is used throughout the book to describe what is usually referred to as cytoplasm) two main questions are briefly discussed, (1) the degree to which the genes on the one hand and the cytoplasm on the other determine the character of development, (2) the degree to which this early determination is permanent or irreversible, (3) the problem of embryonic localization. The evidence for (1) is derived from well known cases of reciprocal hybrids; for (2) from grafting experi-

* EMBRYOLOGY AND GENETICS, *by* T. H. MORGAN. Price $3.00. Columbia University Press, New York, 1934.

ments and for (3) from localized color patterns in mammals. It is concluded (1) that "the early stages of development are determined by the egg protoplasm; only later is the influence of the sperm chromosomes apparent" and further "that the characters that develop in the protoplasm are ultimately traceable to the genes in the chromosomes," although it may take rather long periods of time for the genes to mould or remould the cytoplasm, (2) "when the protoplasm has once become differentiated, the end-product is thereby determined, (3) the problem of localized patterns is unsettled, that is, whether these are determined "by localization in the embryo, or by some other kind of differential, such, for example, as a self-perpetuating protoplasmic element that gets irregularly distributed during early development."

Later chapters deal with larval and foetal types, parthenogenesis, regeneration, localization and induction, sex-determination and physiological embryology. Only rarely are direct allusions made to the manner in which the genes may affect development. One of these is the suggestion put forward that the results (in sex-differentiation) depend directly on the relative rates or speeds at which two competing enzymes develop. This suggestion is not new, but it comes anew from Professor Morgan and indicates a change in his views, although he is still careful to eschew any connection between gene differences and differences in the rate of enzyme development. How the differences may otherwise arise is not discussed. The other suggestion, with which the book concludes, sounds when removed from its context, much more radical. The most common genetic assumption, it is said, is that the genes remain the same throughout development. "It is, however, conceivable that the genes also are building up more and more, *or are changing in some way,* as development proceeds in response to that part of the protoplasm in which they come to lie, and that these changes have a reciprocal influence on the protoplasm." The chief proponent of the stability and integrity of the gene in transmission, appears from this statement to be prepared to abandon the keystone of the theory of the gene when applying it to development. It should be added that the statement is immediately qualified by "if the *basic constitution* of the gene remains always the same, the postulated additions or changes in the genes being of the same order as those that take place in the protoplasm." Nevertheless, many geneticists will question whether a gene with both a basic and other more labile kinds of constitution is the gene with which they have heretofore been familiar. The question, as Professor Morgan concludes, is for the future to decide.

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THE MECHANISM OF DEVELOPMENT

MUCH of the work in experimental embryology during the latter 19th and the early years of the 20th century had an important and evident bearing on problems of heredity. The efforts to discriminate between the functions of the nucleus and cytoplasm by means of interspecific hybrids, and especially by the attempted production of merogonic hybrids, are conspicuous in this connection, and the Roux-Weismann hypothesis of nuclear segregation was at once a theory of development and of heredity. Especially significant was the evidence obtained by Boveri from the viability of blas-

tomeres from dispermic eggs, demonstrating the importance of a complete chromosomal complement for normal development, and strongly indicating the individuality of the chromosomes. In fact, this work, and other embryological work regarding the maternal and paternal chromosomal contributions to the zygote, afforded essential evidence for Sutton's conclusions that the chromosomes are the bearers of the mendelian factors.

Subsequent to this period, however, due perhaps largely to the introduction by Roux of the Entwicklungsmechanik approach on the one hand, and to the preoccupation of geneticists with the behavior of readily observed, and hence chiefly adult, characters, the paths of genetic and embryological research diverged, until in quite recent years it has been possible for writers such as Dürken and E. S. Russell to imply that there is actually a conflict between the two approaches. The writings of Woodger and Bertalanffy are helping on the theoretical side to resolve this apparent conflict, and meanwhile the complementary, and, indeed, interdependent nature of the two fields of research is becoming clear, both in the contributions of the Entwicklungsmechanik school itself and in the shift of attention in a large part of genetic research to the study of the developmental aspects of gene behavior. Consequently, a comprehensive survey of the results of experimental embryology to date merits the attention of geneticist and embryologist alike.

The present excellent volume* offers such a survey, as far as the prefunctional period of development is concerned, with the attempt, where possible, to interpret the large body of available facts in terms of a few general principles (e. g., the gradient concept). It is significant that the principles invoked are still of the order of Roux' "complex components." The authors restrict themselves to analysis on the biological level, both because the material is not yet at hand for an analysis in physico-chemical terms, and because they believe that even when such an analysis is possible, the biological laws will still be valid on their own level. Occasional references throughout the book, however, hint at the advent of physico-chemical interpretations.

In contrast with Morgan's (1927) volume on the same subject, Huxley and de Beer devote relatively little space to experiments on the egg and early cleavage stages (about one-fourth of the volume) and give most of their attention to phenomena during and following gastrulation. A brief description of early amphibian embryogeny is given, derived largely from the studies of Vogt and of Goerttler with intra vitam stains. This is followed by sections on polarity and symmetry, and on cleavage and differentiation. Organizers and gradient-fields are given separate chapters, but the relationship between the two sets of phenomena, pointed out by Huxley ten years ago, is stressed throughout and constitutes probably the volume's most important contribution on the analytic side. On the other hand, the effort to show the relation between "The hereditary factors and differentiation," while it is perhaps successful as far as it goes, is much too brief to do more than touch upon a portion of the suggestive material which has accumulated from diverse sources.

Among the experiments drawn strictly from the field of experimental embryology to which the authors are able to attach genetic significance are some of the well-known results of heteroplastic and xenoplastic grafting in amphibia. Presumtive *neural fold* tissue from a young embryo of *Triton*

*Huxley, Julian S., and G. R. de Beer. *The Elements of Experimental Embryology.* $7.00. Cambridge University Press, 1934.

taeniatus for example, when grafted into the future *gill region* of a *T. cristatus* embryo, gives rise to *gills* (i. e., produces organs appropriate to the site at which it is grafted, regardless of its origin) but the gills have the growth rate and pigmentation characteristic of the *taeniatus* donor, and not of the *cristatus* host. Here, clearly, the "morphogenetic field" into which the graft is placed determines that it develops into gills instead of nervous tissue, and the genetic constitution of the graft determines merely the specific characters of the gills formed. Similar conclusions have been drawn from the experiments of Guyénot, Milojewic, and Weiss, with transplanted regeneration-buds. Recent experiments of Mangold's, however, described elsewhere in the book, show that the genetic nature of the graft may have more far-reaching control of morphogenesis than this. Mangold made reciprocal grafts between *Triton taeniatus,* which possesses a balancer, and the axolotl, which does not, and demonstrated that both species possess an organizer capable of inducing balancer - formation. While Triton epidermis, however, responds to the influence of either its own organizer or the axolotl organizer, axolotl epidermis is incapable of such response and never produces a balancer. Here the genetic constitution of the grafted piece of epidermis determines actually whether or not a given organ is formed, a function which, in the other experiments, was found to belong to the organizer-field into which the graft was placed. It is to be noted, of course, that the (presumably genic) difference between the two species is a difference, not in the organizer-field, but in the peripheral "substrate"; i. e., it is a difference in the capacity of the epidermis to respond to the influence of the organization-field in question. Still a third set of evidence, moreover, part of which is reviewed in the present volume, but is not cited in this connection, indicates that genes may fundamentally alter the morphogenetic field itself. There are several instances known of hereditary homeosis, such as aristapedia in Drosophila, where a leg-like appendage develops in the position normally occupied by the arista. This seems precisely comparable to the phenomenon of regenerating eye-stalks in crustacea, where an antennule is formed in place of an eye, if the optic ganglion has been removed along with the eye. If the eye alone is removed, an eye is regenerated, which suggests that the ganglion is the organizer of the eye. Similarly, in the saw-fly, Cimbex, superficial cauterization of the antenna is followed by the production of a new antenna, but deep cauterization results in the formation of a foot. These facts suggest, as a possible mode of action for such genes as aristapedia, that they affect the morphogenetic field, either by suppressing the particular organizer concerned, or perhaps more likely, in terms of Huxley and de Beer's analysis of serial heteromorphosis, by "flattening" the morphogenetic gradient.

There are necessarily, considering its brevity, many conspicuous omissions in the section on the hereditary factors and differentiation. Some of them are in a measure compensated by treatment elsewhere, such as Goldschmidt's work on wing-pattern development in Lymantria, which is briefly touched on in an earlier chapter. (Lillie and Juhn's analysis of feather pattern, on the other hand, fails to receive more than bare mention anywhere in the book.) Discussion of contributions from genetic investigations which throw light on the problem of differentiation includes little more than a brief consideration of genes as rate-factors, illustrated with Ford and Huxley's Gammarus material, and examples of genes controlling relative growth-rate. Entirely absent is at least one whole series of phenomena which might profitably have been discussed, or at least cited, viz., the developmental aspects of chrono-

some abnormalities, particularly deletions and somatic eliminations. Admittedly, it is the end results of these aberrations which have been chiefly studied, but even these may, on analysis (as in the case of the Minute-reaction studied by Schultz) shed important light on the developmental processes involved. In these aberrations, genetics has, in effect, uncovered a new tool for embryological research, for they provide an interference with the normal mechanism of development beside which the most delicate micro-manipulative technique is enormously crude.

For the remainder of the volume, the authors have, within the limits of their self-imposed restrictions, produced a remarkably comprehensive, comprehensible, and stimulating work. Its clearness is attributable both to lucid style and to an adroit selection and juxtaposition of the experiments presented. Its stimulating character is partly due to the subject matter itself, and partly to the excellent balance between factual material and theoretical analysis. There is sufficient of the latter to be of real assistance in coordinating the immense variety of experimental results, but never enough to warrant the charge that an hypothesis is being pursued for its own sake.

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STERILIZATION FOR TEN MILLION AMERICANS

THE real problem facing industrial civilizations is not human production but human reproduction. Everyone is agreed there are too many people supported by public charity and that many of these are incapable of living the abundant life even in good times. One of the suggestions as to how to eliminate this population of undesirables is to sterilize them, the premise being that they all arise from defective forbears and give birth to defective offspring. This is no new proposal and indeed sterilization laws are part of the statutes of many of the States. So far, official sterilization is restricted to the confirmed felons, the hopelessly feeble-minded, and the badly diseased. Thus restricted even actively practised sterilization does not hold promise of improving humanity rapidly.

Some competent authorities on heredity think we could do better than this and they advocate a more intensive application of the scalpel. This is the point of view that Mr. Whitney undertakes to popularize in his book "The Case for Sterilization."* His is no serious contribution to the science of eugenics for, with commendable frankness, he admits it to be simply propaganda advocating a cause and containing merely opinions. The professional geneticist will find no reason to doubt this admission, but will regret that the author did not apply the same frankness when printing the comments of others on the book cover.†

Leaving this little digression we can take up the book itself. With books on sterilization what every one wants to know is how many are to be sterilized and how it is proposed to choose them? Further, is the choice to be left to legislators and professors or is it to be voluntary?

To the first of these questions the author supplies an explicit answer, namely: at least ten millions should

* WHITNEY, LEON F. *The Case for Sterilization.* Price $2.50. Frederick A. Stokes and Co., New York, 1934.

† Almost all of these "Comments to the Author" are in praise of the science of Eugenics and have nothing to do with the present book. They were actually made years before Mr. Whitney undertook to present this "case." Most of them (if not all) were abstracted from letters written to the Secretary of the American Eugenics Society in 1928. (See department entitled "In Praise of Eugenics" in *Eugenics* for October, 1928, and for February, 1929.)

be sterilized in America but it is possible that provision should be made for withholding from reproduction 25 per cent of the population. The reader will appreciate that this is a large order even in a managed democracy. Those who are to be spared from the scalpel are to be the good ones. The merchant must be a good merchant, the college instructor a good college instructor, and the bricklayer a good bricklayer. If this isn't enough to give a clear picture of the desirable elements we quote "We do not ask that the street-sweeper buy bonds or read Greek; we do ask that he spring from socially adequate germ-plasm, and pass that germ-plasm along to all the little streetsweepers he fathers." Overlooking the broad hint of social stratification implied in that paragraph the reader may feel that he is none too clear in his mind as to just what constitutes a good street-sweeper. That uncertainty puts him in a class with those who believe "we know too little as yet" to undertake such sweeping operations. The reader need feel no embarrassment in being thus classed for he is in good company though the author disposes of all his critics on this score in one of the two chapters devoted to objectors. "It isn't that science doesn't know enough. The trouble is that the critic doesn't know how much science really does know." To prove his point the author gives three ways, not of deciding how to detect good street-sweepers, it is true, but how to decide where sterilization is indicated.

"First it is possible to recognize the great majority of degeneracy-carriers because they commonly exhibit the signs." Perhaps Mr. Whitney can do this but no one else can.

> Second a study of near kin will help us: if we find that Grandmother and Uncle Bob, Aunt Hattie and Cousin Randolph and Mother's brother Bill were all feeble-minded, it is a safe bet that Mother is a carrier; . . .
>
> Third we are able to judge by the first or the second child in a family. If a couple have produced two feeble-minded children, and the index of near kin shows that there has been a lot of feeble-mindedness on both sides, then surely this couple should not be allowed to launch any more children into the world even though the chances are only one in four that the next child will be feeble-minded."

Which boils down to just one way of determining whom to sterilize, namely those whose ancestry embraces an overwhelming proportion of feeble-minded individuals. Thus restricted, no objections will be heard from any but those whose opinions are conditioned by religious training. It also follows that with such feeble-minded persons the operation will not be voluntary on their part but must follow the recommendation of some relative or board. Nor will these cases embrace one-quarter of our population nor even one-tenth.

Mr. Whitney, however, believes that the question of sterilization must not be compulsory—enforced by the State—though every effort must be exerted to *persuade* the defective or potentially defective persons to volunteer. Social pressure and the promise of better things than babies are expected to work the thirty million miracles. "A Sears-Roebuck catalogue offers a thousand choices between a baby and something else that looks pretty tempting."

Having obtained a glimpse of the author's point of view we may consider how he reached it.

The first few chapters are devoted to the description of human sex organs and to reassurance that modern methods of sterilization will not interfere with their use. There follows a chapter on the relation of Mendelism to sterilization which is somewhat misleading in its over simplification of the complexities of heredity and incidentally introduces the novel idea that "what Mendel did principally was to discover that there is a mathematical law governing this matter of inheritance."

The historians should be interested in Chapter VI where we are told that

all the original colonists were able men and that our present population of feeble-minded is wholly due to the selective abilities of Continental officials. If the author is to be believed our immigrants from rather early times were carefully handpicked from the least desirable elements of the European populations. Whether or not the first settlers were genetically superior to the later comers neither Mr. Whitney nor any one else knows. Probably the truth is that our migrating forbears were those who couldn't adjust themselves at home and preferred matching their wits with a primitive race to competing with their betters. As a whole they hardly could be considered as representing the cream of the European germ-plasm.

Of particular interest to readers of the JOURNAL OF HEREDITY is the author's discussion of three articles that appeared in Vols. 8 and 18, one by E. M. East, another by R. A. Fisher and the third a brief letter from Leonard Darwin calling attention to Fisher's calculations. It seems that Mr. Whitney takes issue with these authors chiefly because, for purposes of simplicity of calculation and to err on the right side, they adopt the assumption that feeble-mindedness is determined by a single pair of genes and that normal parents may produce feeble-minded offspring. "All were based not on facts but on an assumption, all argued about a very large *if*."

It is difficult to understand the author's objections to all of these articles. From Mr. Whitney's standpoint it would be hard to discover a serious contribution more in favor of his position than that of Fisher yet he will have none of it.

He prefers to visit the schools for feeble-minded and ask the authorities how many of the pupils have normal parents. When he discovers they are "very few indeed" he concludes:

> No, I can not place any faith, on the basis of all the evidence I have been able to collect, in the theory that feeble-mindedness is a simple Mendelian problem, a trait produced by a single pair of recessive genes—in other words, not inherited from a line of feeble-mindedness. There is no case known in which a pair of feeble-minded parents themselves the offspring of feeble-minded, have produced a normal child; nor is there, to my knowledge, any record of any pair of feeble-minded persons who have come from normal parents and who have married and produced normal offspring, since when such persons are born of normal parents the latter see to it that their offspring do not marry.

This paragraph is about as perfect an example of an author's savagely biting himself as is likely to be found anywhere, and contains nothing whatever in conflict with the hypothesis that feeble-mindedness is a simple Mendelian recessive. Neither does it have much value as evidence that feeble-mindedness is conditioned by a number of factors.

There are the customary chapters on the Jukes, the Kallikaks, and a few others and several little tales in the style of the Russian primer. Two chapters are devoted to commonly expressed objections and these are disposed of to Mr. Whitney's satisfaction.

Since the author's position ". . . is not that of the scientist of earlier days who was supposed to collect facts and was not expected to publish views he had derived from them except in learned scientific monographs that could hardly reach the people" we need not devote ourselves to the scientific aspects of this book. Interest may be focused directly on the probable effect of this propaganda.

Now sterilization has an unpleasant sound of finality to the man in the street, being associated in his mind with the loss of his prize possession. Since for ages past the only surgical method of sterilization has been to convert males to neuters it is going to take skillful effort to persuade the male population to take an active interest in the question. No man worthy of remaining unsterilized is likely to leave to his Government and

the professors the choice of who is to be sterilized so soon as he discovers it is proposed to apply this scientific boon to others than the inmates of asylums and penitentiaries. Nor is he likely to yield his procreational rights through persuasion by his well-meaning and superior neighbors.

If popular support is to be won for this proposal a new term must be devised that will not suggest the ancient surgical technique. Modern methods accomplish the desired end of rendering the patient incapable of producing children without interfering with the art of engendering them. Perhaps the term barrenize will convey the meaning without arousing apprehension.

It should be borne in mind that even though every mental defective, including the grade of moron, submits to sterilization life for the next generation will not be greatly improved. It is not the morons who have created the mischief and misery in the world. Quite the contrary, most of our difficulties are brought about by those whose mental abilities place them above threats of sterilization.

The true case for sterilization is that all those who are certain to give birth to mentally defective offspring should be rendered incapable of so doing as a purely economic measure. How to discover who these prospective parents are, in advance of the event, is a problem even greater than how to get the legal authority to sterilize them. In many cases a competent geneticist aided by good family records could predict feeble-minded offspring with certainty and for these cases sterilization is clearly indicated. The few pages of Justice Holmes' decision in the case of Buck *vs.* Bell are much more effective propaganda for sterilization than the 300 pages of undigested and conflicting material contained in this volume.

Every feeble-minded birth eliminated is at least an economic gain. Those who strenuously advocate wholesale sterilization of the morons are on treacherous ground and are jeopardizing the progress already made in educating the citizens to approve the sterilization of the feeble-minded.

J. H. Kempton.
U. S. Department of Agriculture

"FACTS OF HEREDITY" FOR RACE CONSCIOUS GERMANY

THE thinking people of Germany are coming to be seriously concerned over the population problems with which their country is faced. And well they might be; for probably nowhere else in the world have population changes been so extensive and so disturbing as in that country. "Erblehre und Rassenhygiene"* sets forth the demographic ills that beset the German Republic (if we can properly designate Germany as a republic) and makes an impassioned plea to rouse the people from their lethargy and preoccupation with their personal welfare, so that they will act resolutely and unselfishly in order to become a great, strong, healthy, and prolific people who will assume the dominant position in European affairs to which their superior qualities justly entitle them.

*ERBLEHRE UND RASSENHYGIENE IM VOLKISCHEN STAAT. Teil I und II. Edited *by* Ernst Rudin. Lehmann. Munich, viii + pp., 1934. (Part I of the volume may be purchased separately, 2.80 R. M.)

What Germany needs, it is urged, is a well thought out program of racial hygiene. Let us get rid of our hereditary defectives; let us by all feasible means endeavor to increase the birth rate of the strong, healthy, and intelligent members of the population; and let us preserve our racial purity against contamination by the blood of the Jews and the dull-witted Alpines. The racial doctrines that figured so prominently in Germany before the World War are coming to be voiced with increased fervor since the advent of the Hitler regime. It is noteworthy that several contributors to the present volume take occasion to speak with high praise of the far-sighted and patriotic population policies of the new Chancellor. According to these policies it is necessary, first, to check the decline of the birth rate, for the birth rate in Germany has fallen to an alarming degree. Germany is now in the van of all the low-birth-rate countries in Europe with a rate of only 15 per 1,000 of the population. Even the French, who were looked upon with something of scorn on account of their low reproductivity, have a higher birth rate than the Germans. There is still a surplus of births over deaths in Germany, but, as Burgdörfer shows, this is due to the favorable age composition of the people, and, were it not for this fact, the birth rate would fall far below what is required to maintain a stationary population. Viewed from the same standpoint, the birth rates of the Dutch, the Russians, the Italians, and the Poles are sufficient to insure a rapid increase. Just now the balance of population in Europe is turning in favor of the Slavs, who are increasing about twice as fast as the Germans. Before long the slow increase of the Germans threatens to be followed by an actual decrease, and this shrinkage in face of the growing power of rival nations presents an alarming situation. Something must be done, it is urged, and done resolutely, vigorously, and thoroughly if Germany is not to shrivel to the humiliating position of a third rate power.

The primary task of a Bevölkerungspolitik is to solve the population problem in its quantitative aspects. But properly to carry out this undertaking it is needful to attack the problem of improving the quality of the people at the same time. To this end the Germans, it is urged, should rigidly exclude from entering the country all disrupting and unassimilable elements. Some of the contributors have advocated that the marriage of Jews with people of German stock be forbidden, and that extra-marital relations with people of this unpopular race be visited with severe punishment. The Jewish problem is much in the mind of a number of the authors of this book. What Hitler calls the sins against blood and race ("die Sünde wieder Blut und Rasse") should be combated with all the powers of law and propaganda. The German people must be educated, aroused, and inspired to become, as Burgdörfer has expressed it, "a people of youth, a people of hope, a people of the future; indeed,—I may now make bold to say, *the* people of the future."

It is clearly realized that these ends cannot be secured by education and patriotic declamation alone. Whatever may be done through sterilization and other measures to relieve the population from its burden of defective heredity, and whatever may be accomplished toward the promotion of race purity through the control of immigration and the regulation of marriage, there remains the outstanding problem of increasing the birth rate among the better endowed elements who are now failing to perpetuate their kind. Several proposals are made for equalizing the financial burdens falling upon the parents of the larger families. Perhaps the German people may be aroused to do something really effective in the way of eugenic reform. If so, may Heaven bless them and reward them with success in the struggle for existence!

So much for the first part of the volume, which is devoted to the general problem of Bevölkerungspolitik. The second and larger part deals with special questions occasioned by inherited defects and diseases, and the measures by which these undesirable features may be eradicated. The new sterilization law is explained in detail. The contributors to the volume include several of the most prominent writers in their respective fields, Fr. von Wettstein, E. Rüdin, F. Burgdörfer, H. Roemer, H. Luxenburger, E. Kretschmer, H. F. Hoffmann, Th. Lang, and others equally well known. There is quite a little duplication of material, since each author has followed his own bent, but the volume contains a wealth of valuable information on the important topics with which it deals. To many readers, however, the most interesting and significant feature of the book is the spirit in which several of the sections are written.

S. J. Holmes.
University of California.

A VISIT TO CORBEIL

THE road to the Dionne house led out of Callendar along a dirt road for about two and a half miles. It was so narrow that in many places huge rounded rocks jutted out into the road, and one half of your car went over those. At no place was it wide enough for two cars to pass, and in many places was almost too narrow for one car to go along without the wheels running over the edge. The trees grew so close that their branches touched the top of the car. It being Sunday afternoon, there were literally hundreds of cars from all over Canada and the States going out there, and returning, which meant that the impossible had to be accomplished, and two cars pass. Time after time, you would suddenly round a sharp curve, to find your front bumper nosing the front bumper of a car coming back. Then both cars would stop, each driver would squint back along the trail, see which one was nearest the spot at which he could nose off the road, and then one would proceed to back. Sometimes you forced the car up on to a rounded table of rock maybe twenty feet across, while the other car passed you; sometimes you hung precariously with your front tire wrapped around a poplar tree, characteristic of the north country, while you wrapped the back tire around a neighboring evergreen tree in order to let the other car pass. You would then negotiate another hundred feet only to find yourself in the same predicament, and that time the other car would back, and you would pass, your near mudguards scraping the other car, and your off tires down in the ditch. I am sure that the trip of two and a half miles took well over an hour. But everybody was most good natured about it, and the men drivers would look sheepishly at each other as if apologizing for this silly curiosity of theirs, and a sidelong glance at the women as if it were they who were responsible for making men come out just to see where five babies were born.

The country was barren, after the first mile and a half of dense undergrowth was passed, with huge rocks, poor pastures, and here and there a bit of soil with a few stalks of grain. Those of us who think that the log cabin days have passed should take this trip, for many of the houses were log cabins, white-washed, but

with much of it washed off, leaving that forlorn look which weather-beaten wood has that has once been covered, and no longer is. The houses appeared to be one room mostly, or if more, certainly not more than two. The Dionne home was one of the better looking houses along the road from Callendar to Corbeil. There was no doubt of the home, for as you approached it, there was a line-up of cars worthy of a first night at the opera and on several lines across the yard and on the porch, what appeared to be hundreds of napkins fluttering. The scarcity of grain in the fields, the fewness of the cows and chickens, the dearth of horses, made the observer wonder what they did for a living, what they ate, what they sold. Apparently in the old days, the country had been well lumbered over, and the inhabitants continued to live there when there was little livelihood left on the farms.

At a little table in the front yard, the father and grandfather were selling post cards of the babies. When one realized that in that house were living the parents, the grandfather, the five older children of the family, the five quintuplets, and the two nurses who were on duty, one could only guess at where they were all kept. Perhaps the thing that impressed me most was that under what were distinctly not the sanitary surroundings desirable for maternal welfare, this woman had given birth to six children, all of whom survived the infant period, and now to five more who were living.

Constitution is certainly a part of the answer, for environment here was all for maternal death and infant mortality. Some women with the best obstetric care in the most modern of hospitals succumb. Here under conditions far from ideal, this woman has come uneventfully through seven pregnancies, and five of her former six children and all the quintuplets are living.

But with the best heredity in the world they could not have survived had there not been a man of ability to bring them through. I had the pleasure of meeting Dr. Dafoe, and in this doctor of the village of Callendar, I found all the best traditions of the medical profession exemplified. With his remuneration the satisfaction with work well done, with little to work with, with almost insurmountable difficulties to be met, he has assembled in this out of the way place, modern machinery for caring for the babies, begged for incubators, begged for human milk, driven around the country getting it from other mothers until the supply from outside was sufficient to meet his requirements, playing the rôle of sanitary inspector, family adviser as well as physician, general clearing house for the numerous gifts which began to pour in, these are some of the duties, some of the responsibilities which this man has had to meet. Nor does one have to elicit this from the doctor himself. Much of it can be gleaned from observation.

Again what impressed me was that with a determination sufficiently great, even the obstacles of the environment could be overcome, and medical science triumph in the backwoods as well as in the best equipped hospitals. Many a doctor without his resourcefulness, without his ability to use what he had at hand, and turn it to his account, would do well so long as he had all the apparatus of a modern hospital at his command; but he would have been lost in dealing with the situation here. One glance at Dr. Dafoe's well stocked library, is enough to tell one that a country practice does not preclude one's being abreast of the times.

Oddly enough this seemingly isolated spot has become the mecca for others besides the curiosity seekers. Here one might meet with consultants from the best universities in the land. We passed Dr. Kelly of Johns Hopkins as we were

going out there; Dr. Kelly having come to give radium treatments to one of the babies for a tumor on her leg.

Palm and foot prints have been taken, and as they grow older, the scientific world will await with interest further data upon their physical and mental development, upon their blood groups, and upon any other information dealing with the eternally interesting question of the interaction of heredity and environment.

MADGE T. MACKLIN.

EDITOR'S NOTE: The *Journal of the American Medical Association* for September 1 carries a most interesting article by Dr. Allen Doy Dafoe giving the obstetrical details of the birth of the quintuplets and their subsequent history to an age of two months. His concluding remarks on the advantages and disadvantages in the enormous publicity the event has received are of considerable interest and are quoted in full:

"The publicity in connection with this case has been a serious problem and has caused me considerable trouble and worry. There has been no let-up from the moment of the uncle's naive enquiry to the North Bay paper as to how much it would cost to insert a birth notice for five babies born at one time. At first I resented what I felt was an intrusion into my private and professional affairs. Then I came to realize that I had no right to object to what had become a matter of continent-wide interest. I have been increasingly grateful to the newspapers for the invaluable supplies and equipment which from the beginning came as a result of this publicity. As for myself, I have had an opportunity which I could never otherwise have enjoyed of meeting by letter, or in person, some of the outstanding men of our profession in Canada and the United States."

◆

Books Received

BOOKS are acknowledged in this column as received, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. As far as space permits, books that contain material of special interest to the readers of the JOURNAL *will be reviewed in later numbers.*

THE SELECTION OF COLOUR WORKERS, *by* W. O'D. PIERCE, B.Sc. (Tech), M.Sc. Pages 134. Price $2.00. Pitman Publishing Corporation, New York, 1934.

Being a research into the practical methods of measuring the ability to discriminate fine shades of colour.

THE FAMILIES OF FLOWERING PLANTS, *by* J. HUTCHINSON, F. L. S. Volume I, Dicotyledons, 328 pages, index, 264 illustrations. Price $6.00. Volume II, Monocotyledons, 243 pages, index, 107 illustrations. Price $6.00. Macmillan and Co., Ltd., London, 1934.

COMPARATIVE PSYCHOLOGY, Edited by F. A. Moss. Pages 529, indices. Price $3.50. Prentice-Hall, New York, 1934.

THE RESTRICTIVE LAW OF POPULATION, *by* JOHAN HJORT. Huxley Memorial Lecture, 1934. Pages 46. Price 1/1. Macmillan and Co., Ltd., London, 1934.

THE CHILD, *by* MEYER F. NIMKOFF. pages 303, index. J. B. Lippincott Company, Philadelphia, 1934.

THE FAMILY, *by* M. F. NIMKOFF. Edited by William F. Ogburn. Pages 526, index. Price, $5.00. Houghton Mifflin Company, New York, 1934.

RONTGENOLOGISCHE SKELETT-STUDIEN AN MENSCHLICHEN ZWILLINGEN UND MEHRLINGEN, *by* FRANZ BUSCHKE. Pages 47 and 50 plates. Price M 25. Georg Thieme, Leipzig, 1934.

SCIENCE, RELIGION, AND MAN, *by* REV. W. J. J. CORNELIUS. Pages 387, index and bibliography. Price 15/. Williams & Norgate, London, 1934.

WHY WE DO IT, *by* ARTHUR R. DAVIAU. Pages 231, price $2.00. Meador Publishing Company, Boston, 1934.

A study of normal, subnormal, and abnormal human behavior.

PRINCIPLES OF ANIMAL BIOLOGY, *by* A. FRANKLIN SHULL with the collaboration of George R. La Rue and Alexander G. Ruthven. Pages 400, index and glossary. McGraw-Hill Book Company, Inc., New York, 1934.

EARLY FORERUNNERS OF MAN, A Morphological Study of the Evolutionary Origin of the Primates, by W. E. LE GROS CLARK, D.Sc. (Lond.), F. R. C. S. (Eng.). Pages 296, index, 89 illustrations. Price, $5.00. William Wood and Company, Baltimore, 1934.

POST-NATAL GROWTH DISPARITY IN MONOZYGOTIC TWINS

TAKU KOMAI AND GORO FUKUOKA*
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USUALLY the difference between monozygotic twins does not increase with age but rather it tends to decrease as the twins grow older. It is only in a very few cases that such twins develop striking physical differences after birth. Siemens reported an instance of such a post-natal change in monozygotic twins.[3] Here we have another case which is even more interesting because the difference is apparently due to a rare disease from which one of the twins is suffering.

The twins are fifteen year old boys, the sons of a merchant couple, and pupils of secondary schools in the city of Osaka. As will be readily seen in Figures 13 and 14, they show a striking difference in body build. In stature the larger twin *F* measures 154.8 cm. while the smaller *M* is only 140 cm.; *F* weighs 44.81 kgm., while *M* weighs 34.42 kgm. Other measurements taken by us in March 1931 and in April 1933 are shown in Table I. It may be seen from this table that the differences between the twins in height amount to about 10 per cent in most of the measurements taken, while in body weight there is about 30 per cent difference.

F is right-handed and right-footed, while *M* is left-handed and left-footed to a fairly strong degree. *M* uses his left hand for striking a match, for holding a pen-knife in sharpening a pencil, for holding scissors, and for throwing a ball; but he holds chopsticks and a writing brush with his right hand; *F* does all these things with his right hand. In Collins' hand-dynamometer test *M* scored 17 (R) and 20 (L), *F* scored 25 (R) and 11 (L). In a tapping test *M* scored 151.7 (R) and 155 (L), while *F* scored 158.2 (R) and 136 (L).† *M* kicks a foot-ball with his left leg, *F* prefers to use his right leg. It may be mentioned here that the parents and other sibs are all right-handed. The mother's father however, seems to have been ambidextrous, according to the mother's statement. It is difficult to say whether the left-handedness of *M* was inherited from his grandfather or developed epigenetically. *M* has diabetes insipidus, from which *F* is entirely free.

In temperament the twins are somewhat different; *M* is more alert and nervous than *F* who is more steady and reserved. In intelligence tests *M* obtained somewhat better scores than *F* (Tables 4-6.)

Evidence of Monozygosity

Notwithstanding the great differences in body build the twins show striking similarity in physiognomy, finger, palm and sole patterns and in certain mental characteristics, so that their monozygosity is almost beyond any doubt. As to physiognomy, no description could be more accurate than the photographs in Figures 13 and 14. The twins have some distinctive facial characteristics in common. Their facial resemblance is striking yet they do not resemble the other sibs. In fact the similarity between the twins in facial appearance is such that were the difference in body build not so great, it would be pretty hard for anybody to tell the twins apart. However, *M* has a proportionally larger head and short-

*The authors wish to express here their appreciation of the hearty cooperation of the twins and their parents without which this study could never have been made. They are also grateful for the valuable assistance given them by Doctors A. Hagi, K. Iwai, T. Iwai, Fujino, S. Nishizaki and M. Takino.

†These tests were made in March, 1931.

THE TWINS DURING CHILDHOOD

Figure 13

The twins at one year of age (above); at about five (lower left) and two views at twelve years two months (lower right). These photographs prove that the difference in development which now is so striking did not begin to make itself manifest until after the twins had reached their fifth birthday.

er face than *F*, as is clear in Figure 13 and Table I.

The identity of the finger patterns of the twins is even more remarkable, and stands in a sharp contrast with the rather great differences found among the finger patterns of the parents and other sibs (Figure 15). Table II shows this fact more clearly. The twins have loops of low value on all fingers, so that the quantitative values of all fingers taken together according to Bonnevie's scheme are low and nearly equal (*F*. 29.0, *M*. 28.5). The parents and other sibs have whorls and loops of higher value, so that the total quantitative values are much higher and show great differences among themselves.

The palm patterns present much the same tendency as is shown in Table III and Figure 18. Both of the twins have an ulnar loop on their left palms only, so that the resemblance between their two left palms is closer than that between the right and left palms of one of them. The similarity of their sole patterns is not very marked but still the same sides match each other fairly closely, and stand in rather sharp contrast with the sole-patterns of the rest of the members of the family (Table III). In the shape of ears, in the colors of iris, hair and skin as well as in voice, the twins are very similar. They are both near-sighted, *M*, however, being more so than *F* (*F*, L. R. O. 9 D: *M*, L. 1.5 D, R. 2.0 D). The saliva test was given the twins and the other members of the family by Dr. A. Hagi, and it was found that the twins both belong to the A type. The results for the other members of the family were as follows: father=A, mother=O, *K* (♀)=A, *T* (♂)=A, *Y* (♂)=O. The class records of the twins in their primary school are practically identical; both stood very high in the class. For instance, in their fifth school year *F* was the second, and *M* was the third of the class of 46. At the present time they are enrolled in different schools and the comparison of their school records is not possible for this reason.

THE TWINS AT FIFTEEN

Figure 14

They differ fourteen kilograms (about thirty-one pounds) in weight and by several inches in height. The change in growth rates is correlated with the development of diabetes insipidus in *M*, probably as a result of differences in the activity of the pituitary body (see Figure 16).

Birth and Development

The twins' mother who is an intelligent woman, remembers well the details of the delivery of the twins which was her first labor. She even saw the after-births. The twin babies came within a very short interval. The placenta was single, large, elongated and curved, and had two umbilical cords attached separately. Between the roots of the cords was a membraneous

septum containing a network of blood-vessels. This description of the septum does not indicate that the twins are monozygotic but their close correspondence in the important bodily features, such as physiognomy, finger, palm, and sole patterns seems to outweigh this statement made by the mother. The babies had exactly identical body weights and head circumferences, when they were measured immediately after birth. Figure 13 shows the twins at one year of age. The twins were both breast-fed; the parents took every caution to enable them to rece.ve equal treatment. The resemblance of the twins to each other in their early childhood was so great that it was necessary, especially for the father and grandfather, to tie strings of different colors to the boys or to mark one of them with an indian-ink spot on one ear-lobe in order to avoid confusion. Up to school age, the bodily features of the twins were nearly identical, and both contracted the same uninfectious diseases simultaneously. On the whole, the twins enjoyed good health, and their rate of growth seems to have been nearly the same. This is well shown by the group

TABLE I. PHYSICAL MEASUREMENTS OF THE TWINS.

	March 1931			April 1933		
	F	M	F/M	F	M	F/M
Stature	130.6	127.4	1.10	154.8	140.0	1.10
Sternal height	113.2	104.5	1.08	135.6	113.3	1.11
Height of navel	86.1	78.4	1.10	98.5	84.9	1.12
Sitting height	74.2	68.0	1.09	80.2	72.7	1.10
Height of symphysis	74.6	69.5	1.07	79.4	73.1	1.09
Height of acromion	113.0	102.9	1.10	136.6	114.0	1.11
Height of tip of middle finger	80.9	47.0	1.07	97.3	81.9	1.10
Biacromial diameter	33.8	30.0	1.13	36.3	32.4	1.12
Biiliacal diameter	24.4	20.7	1.18	29.7	26.3	1.13
Arm stretch	130.2	127.2	1.02	167.7	139.7	1.13
Length of right arm	62.6	56.1	1.12	68.7	57.5	1.19
Head length	17.2	17.4	1.02	18.2	18.1	1.01
Head breadth	15.3	14.8	1.03	15.4	15.0	1.03
Head index	86.0	88.3	1.01	84.6	83.2	1.02
Bizygomatic breadth	11.5	10.5	1.10	12.5	11.8	1.06
Face length				17.0	16.5	1.03
Body weight (kgs.)				44.81	34.42	1.30

TABLE II. FINGER-PATTERN FORMULAE OF THE FAMILY.

Finger		I	II	III	IV	V	Quantitative value
Father	L	6-20	10-9	0-12	2-14	0-14	48.0
	R	0-19	0-8	0-10	9-11	0-16	
Mother	L	14-22	9-14	0-10	0-13	9-17	54.0
	R	14-21	0-13	0-13	0-15	0-16	
F	L	0-21	8-0	0-3	0-8	0-14	29.0
	R	0-21	8-0	0-4	0-7	0-9	
M	L	0-20	3-0	0-4	0-8	0-10	30.5
	R	0-24	0-5	0-6	0-9	0-11	
K	L	11-19	11-16	0-12	10-13	11-15	64.9
	R	17-21	4-13	0-13	1-15	4-16	
Y	L	12-23	0-10	0-11	14-14	10-15	59.0
	R	11-21	0-15	0-14	0-16	0-15	
T	L	16 -20	10-14	4-14	16-19	15 -16	78.0
	R	20-16	11-16	5 -15	15 -20	14-16	

TABLE III. PALM- AND SOLE PATTERN FORMULAE OF THE FAMILY.

		Palm Pattern	Sole pattern
Father	L	9-7-6-1-6 / 6	12-8-1-1-1 / 4
	R	10-7-6-2-6 / 14	14-14-14-14-1 / 0
Mother	L	7-6-6-2-6 / 26	12-8-7-6-12 / 4
	R	8-7-6-6-6 / 26	12-10-8-6-12 / 6
F	L	8-8-6-2-6 / 14	14-8-8-14-12 / 12
	R	10-8-6-2-6 / 30	14-14-12-10-12 / 4
M	L	8-8-6-1-6 / 14	14-11-8-14-12 / 2
	R	11-8-7-1-6 / 30	14-8-7-7-13 / 44
K	L	7-6-6-1-6 / 4	14-14-14-13-10 / 0
	R	8-6-6-2-6 / 28	14-14-14-13-13 / 0
Y	L	7-6-6-2-6 / 28	14-8-7-11-13 / 4
	R	10-8-6-6-6 / 50	14-14-14-14-14 / 0
T	L	8-8-6-3-6 / 28	14-14-12-10-13 / 46
	R	10-10-6-4-6 / 28	14-14-12-10-13 / 46

TABLE IV. SCORES OF KIRIHARA'S GENERAL INTELLIGENCE TEST (B)

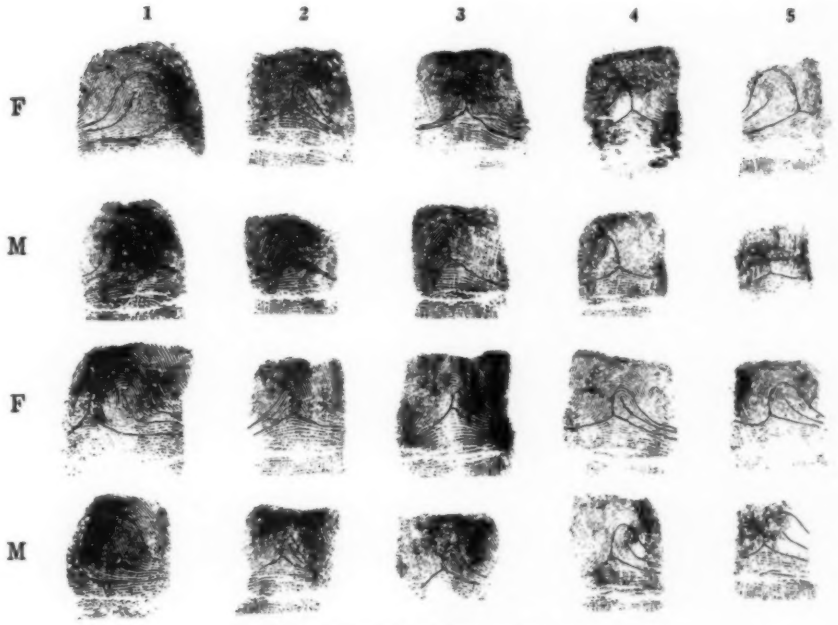
	F	M
Test 1. (Completion)	18	20
2. (Analogy)		
3. (Recognition)	20	16
4. (Rybakov figure)	10	8
Totals	48	44

TABLE V. SCORES OF KUBO'S GROUP INTELLIGENCE TEST SCALE A. (NATIONAL INTELLIGENCE TEST, SCALE A. FORMS I & II, REVISED SO AS TO SUIT JAPANESE CHILDREN)

	F	M
Test 1. (Arithmetical reasoning)	22	24
2. (Sentence completion)	26	26
3. (Logical selection)	19	21
4. (Synonym-antonym)	27	29
5. (Symbol-digit)	29.7	31.5
Totals	123.7	140.5
I. Q.	103	108

TABLE VI. SCORES OF KUBO'S GROUP INTELLIGENCE TEST, SCALE B (NATIONAL INTELLIGENCE TEST, SCALE B, FORMS I & II, REVISED SO AS TO SUIT JAPANESE CHILDREN)

	F	M
Test 1. (Computation)	30	34
2. (Information)	18	20
3. (Vocabulary)	20	31
4. (Analogies)	15	17
5. (Comparison)	34	32
Totals	117	134
I. Q.	103	121



FINGERPRINTS VERY SIMILAR

Figure 15

The fingerprints show the close resemblances in patterns characteristic of most identical twins, and in connection with the other similarities are strong evidence that the twins are monozygotic.

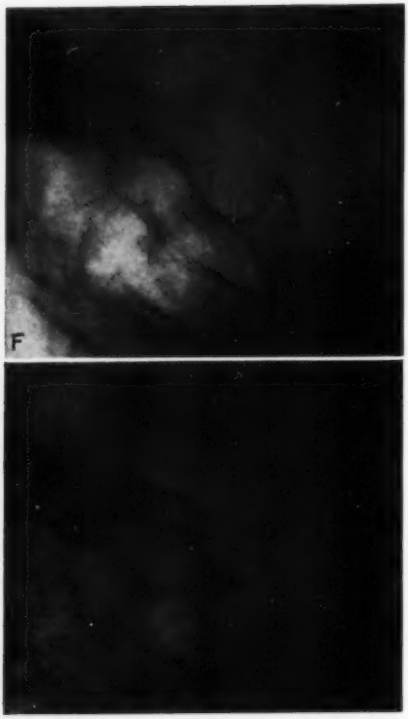
photograph (in Figure 13), which was taken the year before their entrance to the primary school.

In the second primary school year of the boys' however, the parents came to notice the difference in the rate of growth of the twins. As a matter of fact, the school physical examination records show clearly that, at the time of entrance to the school, there already existed a difference between the twins in stature and in weight. But probably the difference was too small, (especially the difference in stature which was only 3 per cent), to be noted by the parents. The difference grew more significant with age. In the second and third years the difference in stature became 8 per cent and that in weight 20 per cent; in the fourth year, the difference in stature amounted to 10 per cent and that in weight to nearly 25 per cent, according to the same records (Figure 17).

Diabetes Insipidus of Twin *M*

A little after the time when the parents first noticed the difference in growth rate of the twins, the smaller twin *M* began to show striking habitual thirst. He would drink large quantities of water at short intervals. The symptom of polyuria also became apparent. As the boy grew older the frequency of drinking and miction decreased to some extent; but the symptoms of habitual thirst and polyuria are still apparent. Otherwise, the boy has enjoyed very good health and has missed only two school days in eight years. The larger twin *F* also has been healthy; he missed his classes seven days in the same period.

The twin *M* showed unmistakable



DIFFERENCES IN THE DEVELOPMENT OF THE PITUITARY GLAND

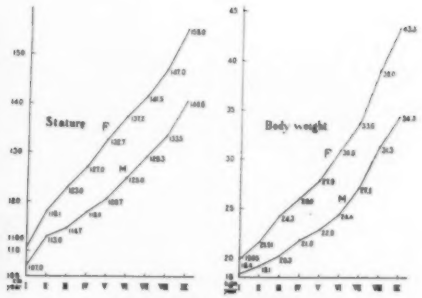
Figure 16

The sella turcica, located in the skull at the base of the brain, contains the pituitary body, which has profound influences on growth and metabolism. The fact that there is a marked difference in the size of the sella turcica may be taken as evidence of a difference in activity of this gland.

symptoms of diabetes insipidus. He was taken for examination to Dr. M. Takino of our university clinic, who is an expert in this type of diagnosis and the doctor confirmed our view of the boy's disease beyond any doubt.

Sella Turcica

Thus in the smaller twin *M*, the retardation of growth and the diabetes insipidus seem to be related intimately. This notion aroused in us a desire to examine the state of sella turcica of *M* in comparison with that of *F*. Fortunately, through the kindness of Dr.



GROWTH CURVES

Figure 17

Curves showing the development of the twins in stature and in body weight according to school records. The record extends from the sixth to the fourteenth year of the twins' age. Even at six years definite differences in stature and weight are to be noted.

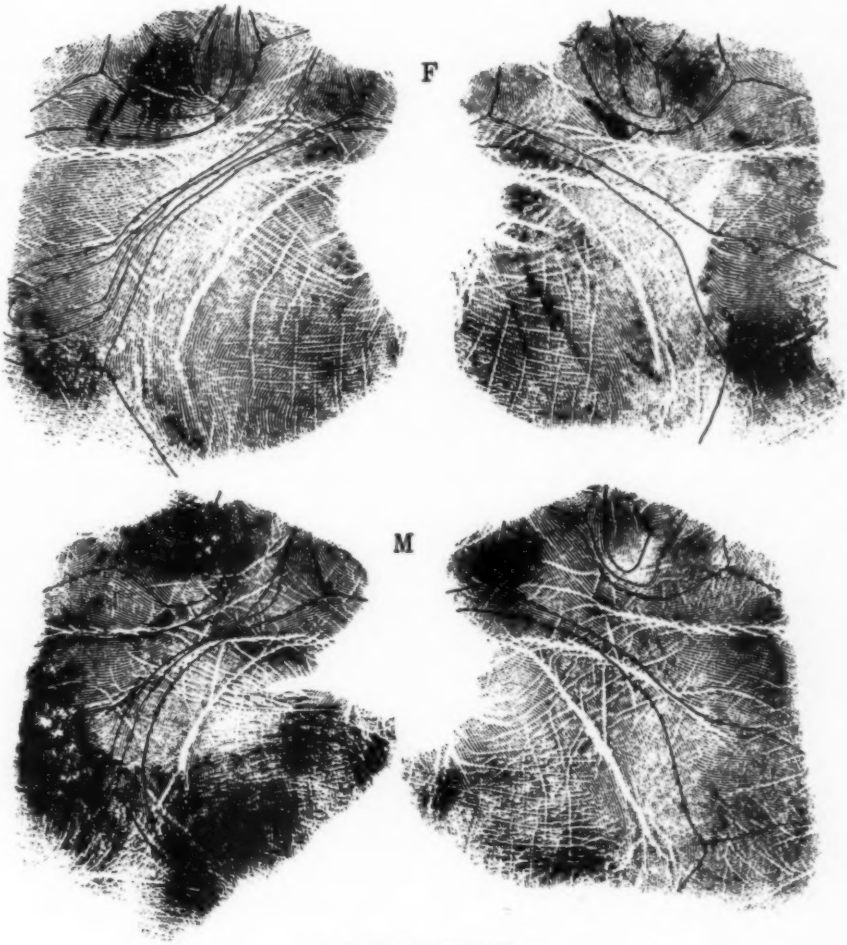
S. Nishizaki of St. Barnabas' Hospital in Osaka, we were able to secure the help of Dr. Fujino, a Röntgen expert of the Osaka Imperial University Clinic. Photographs of the Turkish saddles of the twins, taken with Takagi's method, are shown in Figure 16. The difference is clear at a glance. The measurements of the pituitary fossae are as follows:

	F	*M*
Antero-posterior diameter (mm.)	12.5	10.1
Depth (mm.)	7.7	7.2

On the whole, the pituitary fossa of *M* is smaller than that of *F*, although it can hardly be considered abnormally small. It is probable that this is responsible for the pronounced difference in the bodily development of the twins and also for *M*'s diabetes insipidus. However, careful Röntgen examinations of the arms and legs of the twins show hardly any difference in degree of ossification.

Discussion

It may be questioned whether it is right to diagnose these twins as monozygotic. Besides the striking difference in body build, the mother's statement about septum on the pla-



PALM PATTERNS

Figure 18

The two right hands and the two lefts resemble each other much more closely than the respective pairs resemble each other. Such mirror-imaging is important evidence that the twins are "identical" in spite of their differences.

centa seems opposed to this diagnosis. However, the state of the septum apparently fails to give correct diagnosis of the zygosity of twins in some exceptional cases (Komai and Fukuoka[2]). In the twins under consideration, several important bodily features, such as physiognomy, finger, palm, and sole patterns which are commonly recognized as criteria for distinguishing monozygotic and dizygotic twins, give unquestionable evidence of the monozygosity of the pair. Moreover, there is no question that the twins were very similar to each other in body build in their early childhood. Thus it seems to be reasonable to infer that the twins

are monozygotic and that the striking difference has developed since they became of school age. Coincidentally with the beginning of this pronounced disparity in development, diabetes insipidus appeared in *M*. It has been demonstrated that the pituitary fossa of *M* is somewhat smaller than that of *F*. Consequently, one seems to be justified in assuming a causal relation between the underdevelopment of the pituitary body and the retardation of bodily development and diabetes insipidus in *M*. However, nothing is known of what brought about such a change in the pituitary body of *M*. No trace of diabetes insipidus is present in either the father's or mother's line, so far as they know. The boy had never contracted the disease which is usually known as causing diabetes insipidus, e. g., meningitis. Wasserman's and Meinicke's tests gave definitely negative results.

Being a monozygotic pair, these twins probably started their development with the same sets of chromosomal genes. There are three possible genetic explanations for this marked growth disparity. The cytoplasm, may have been somewhat different. Both the chromosomal complex and cytoplasmic constitution may have been identical, but the pituitary body of *M* might have received some unknown haphazard check during development. A gene mutation of a kind which interferes with the normal development of the pituitary body may have occurred in him. The material is too meager to enable decisive choice among these possibilities. At any rate, this case of monozygotic twins is interesting from the viewpoint of the pathology of twins because (1) they show a striking post-natal difference in growth-rate (2) only the smaller twin has diabetes insipidus and (3) the retardation in growth and diabetes insipidus in him are probably the outcome of the imperfect function of the pituitary body.

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For further bibliography, see the authors' paper of 1931 (2).

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A Glossary Of Technical Terms

Used In This Issue

GENETICS has developed so rapidly that many terms in common use in genetic literature are not yet incorporated in the dictionaries. Many people who are interested in heredity are bothered by such words, for which no definition can conveniently be found. For this reason, it is proposed to publish occasionally a glossary of terms which would not be readily understood and which are not to be found except in new unabridged dictionaries. It is realized that these definitions will probably not meet with universal approval and comments and suggestions will be welcomed.

ATHYROSIS—Absence of the thyroid.

BACKCROSS—Cross of a hybrid to one of the parental forms.

BLASTOMERE—One of the large cells formed as a result of the first few cell divisions of the egg.

CHARACTER (a contraction of characteristic)—A term used, often rather vaguely, to designate any form, function, or feature of an organism. The Mendelian characters of genetics represent the end-products of development in which a definite gene, or genes, have a decisive effect. "The constant and unchanging thing, therefore, is the factor (gene) itself rather than the character, and the unity which Mendel observed lies rather in this underlying factor than in the visible, and perhaps variable, character which it produces."—Sinnott and Dunn.

DISPERMIC—Fertilized by two sperm cells.

EPIGENESIS—The theory of generation holding that the germ or embryo is created entirely new, not merely expanded and unfolded by the procreative power.

GENOTYPE—The entire genetic constitution, expressed and latent, of an organism.

HETEROGAMETIC—Producing unlike gametes (with respect to the sex chromosome). In the "X-Y" group of organisms the male is the heterogametic sex, producing *X*-bearing sperm and *Y*-bearing sperm in equal numbers. In the "*W-Z*" group (including moths and birds) the female is heterogametic, producing *W*-bearing ova and *Z*-bearing ova, the sperm-cells all carry a *W* chromosome.

HETEROPLASTIC GRAFT — Transplantation of tissue from an individual of one species to an individual of a different species or even a different genera.

HETEROZYGOUS—Containing both genes of an allelomorphic pair, or two genes of an allelomorphic series. Heterozygous individuals generally resemble the individuals homozygous for the dominant character, but they transmit the recessive to half their offspring.

HOMEOSIS—The assumption by one of a series of parts of the characters proper to another member of the series.

HOMOZYGOUS—(1) An organism formed by like germ cells; (2) An organism is said to be homozygous for a given character when all the germ cells transmit identical genes for this character. This is the most frequently used meaning of the term.

HYPERPLASIA—An abnormal or unusual increase in the elements composing a part, as of the cells of a tissue.

MEROGONIC—From a portion of an egg.

MONOFACTORIAL—Controlled by a single gene (factor) in inheritance.

MORPHOGENESIS—The development of characters.

MUTATION—Where a heritable variation begins. A sudden variation in an inherited character.

OUTCROSS—A cross to an individual not closely related.

PHENOTYPE—The organism as exemplified by its expressed characters, as contrasted with its genetic constitution (the genotype).

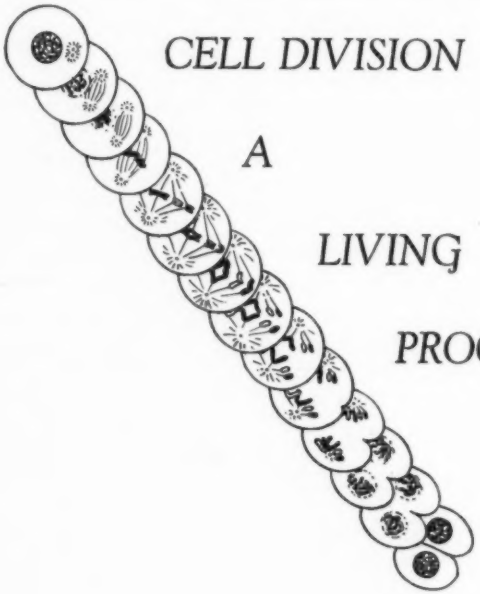
SEGREGATION—Separation of allelomorphic genes at meiosis.

SEX-LINKED—Applied to characters carried on the sex-chromosomes—characterized by typical peculiarities in inheritance as a result of this fact.

SOMATIC—Referring to body tissues; having two sets of chromosomes, one set normally coming from the female parent and one from the male; as contrasted with germ cells having a single set of chromosomes.

XENOPLASTIC GRAFT—A heteroplastic graft that "takes" and continues to develop in its new site (most heteroplastic grafts are short lived).

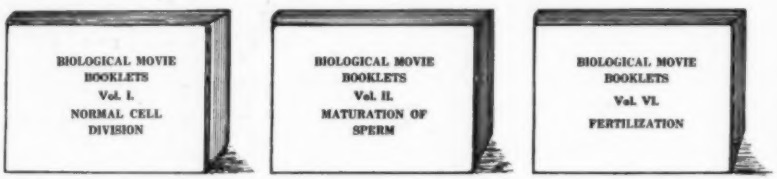
ZYGOTE—A fertilized gamete. Produced by the fusion of sperm and ovum. A new individual in the single-cell stage.



CELL DIVISION

A LIVING PROCESS

The fixed cell viewed under the microscope is a dead cell. "Prophase," "Metaphase," and "Telophase" are descriptions not of static conditions but are really fleeting glimpses of a continuous process whose essence is change and movement. The Biological Movie Booklets "bring to life" through a simple application of the "movie" principle in booklet form three important vital processes involving cell division:



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